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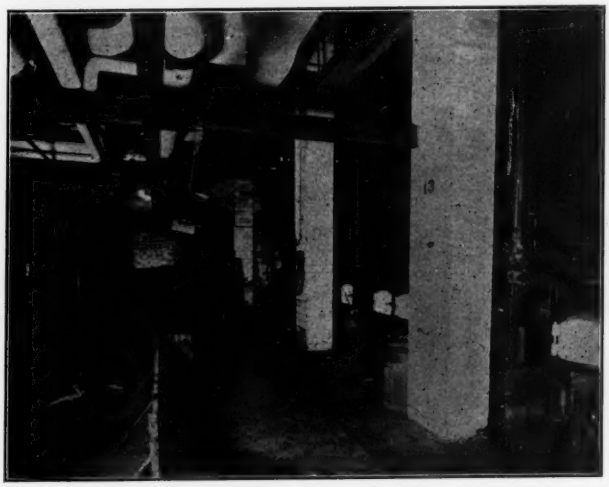
RETURN TO 207 MARKET ... NEWARK, N. J.

POWER PLANT OF THE ST. REGIS HOTEL

One of the Most Elaborate and Expensive Hotel Plants in New York City

There is an old saying that one-half the world does not know how the other half lives. This is especially true when applied to the knowledge which is lacking about how the very rich live and enjoy themselves. By the very rich is meant today a comparatively larger number of persons than could be classed under that heading a score of years ago and includes those persons whose wealth runs well into eight figures. Many of these people have acquired their wealth in the more recent years and to satisfy their wants has become one of the hardest problems to solve. They not only must have the most expensive homes with every conceivable appliance which adds



Boiler Room of the St. Regis Hotel

toward their comfort, the most expensive luxuries, the finest horses and carriages, but growing tired of their own extravagances, they usually as a last resort turn to hotels to give them what it is almost physically impossible to provide in any other way. Consequently, any hotel which can show the most expensive and exclusive furnishings, table service and mechanical appliances which add to the comfort, is almost sure to have the patronage of the very rich.

New York, with its hundreds of millionaires, has more fine hotels than any city in the world, and it is in that city where wealth runs riot. The latest hotel in New York to which all wealthy eyes are turned is the St. Regis Hotel, located at Fifth Avenue and Fifty-fifth Street. Nobody can be found who has been willing to say exactly what this eighteen-story hotel costs, but popular rumor has it that $8,000,000 is not too high when the cost of the furnishings is considered. It is not a large hotel, as modern hotels go, but its richness is therefore all the more concentrated.

An idea of how so much money has been spent to make life comfortable for the comparatively few guests who are sheltered under its roof can at once be gained by entering the front door. The floors are of Irish marble, dallage and mosaic and every piece of metal work, such as elevator doors, chandeliers, counter railings, balustrades, are separate, individual works of art in bronze. The walls are lined with shaded marble surmounted by panels and carved pilasters of expensive stone. Then the dining rooms draw attention and the artistic marble, bronze and decorated work is so elaborate that they cannot be described. On the second floor are the brown English oak library, the banquet hall, which is lined from floor to cornice with polished white Vermont statuary marble, and the reception halls of walnut and white mahogany. On the third floor is located the state suite, which is perhaps the most beautiful and expensive set of rooms in New York City.

Before descending into the engine room, it might be interesting to know also what are on the other fifteen floors, but, without going into detail, it is sufficient to say that every hall from the ground to the roof is lined throughout with polished marble and even the frames of the doors are so constructed. Every suite has its bath-room with porcelain bath and silver-plated plumbing. Every room has its magnetic clock regulated from the master-clock, below in engine room. Each suite has its long distance telephone. Every floor has its service pantry, which has its own warming closets, refrigerators and each pantry is connected with the kitchen below by telephones, pneumatic tubes and electric dumbwaiters.

The heating and ventilation have been designed so that no particle of dust is ever breathed in by its fastidious guests, the outer air having no admittance until it has passed through a long series of cheese-cloth filters which take up a barrel of dust a day which otherwise would be breathed in. The purified

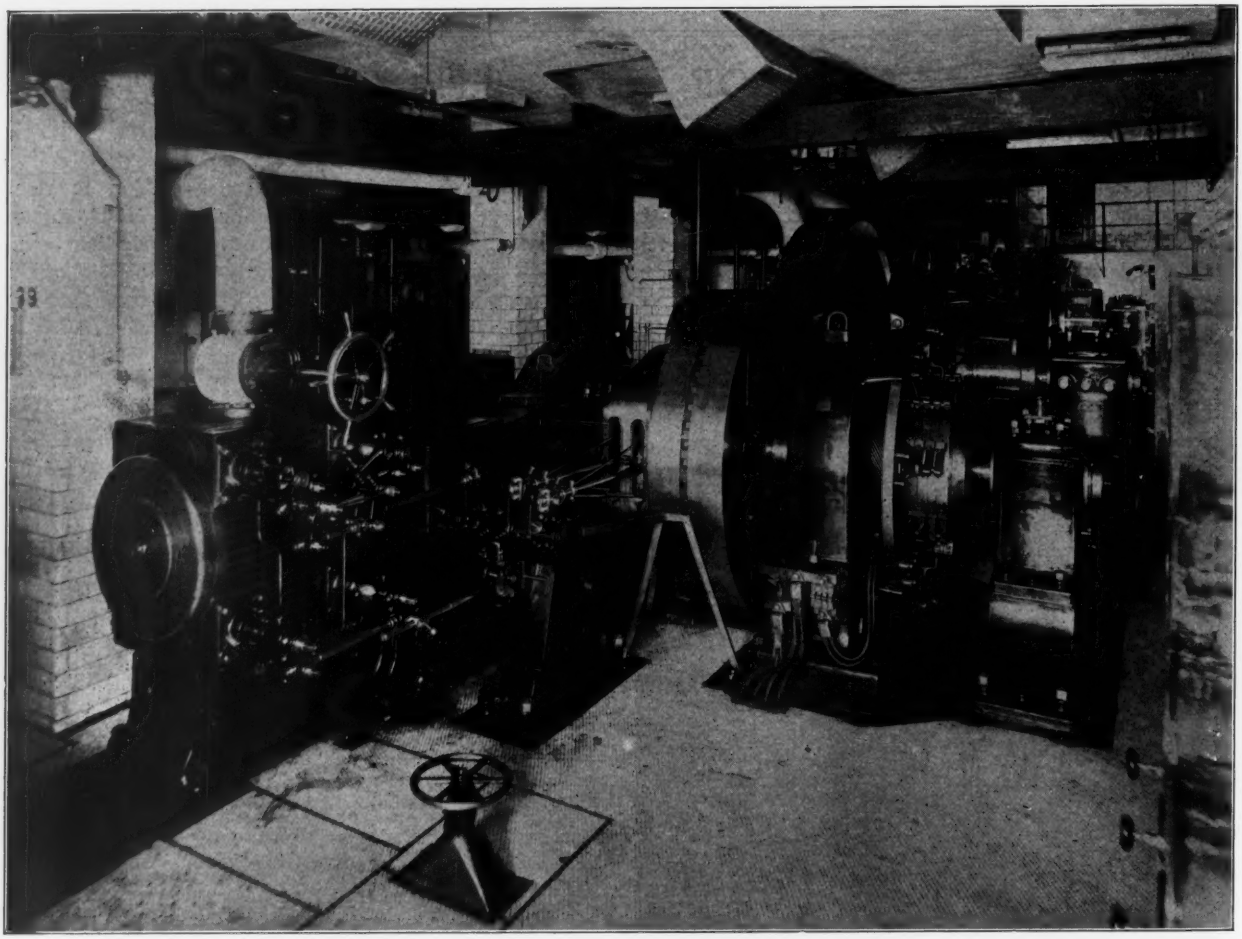
air then passes from the filters to a chamber which is moistened or dried so that the humidity of the air in the hotel is always the pleasantest. The air is then heated in winter or cooled in summer by refrigerating pipes or steam coils, after which it is blown through ducts to every part of the building by means of electric blowers. There is a thermostat in each room and hall which automatically regulates the temperature, and the room can be kept at any desired temperature by simply turning the dial to the desired degree.

No brush or broom is ever allowed to enter the living apartments of this hotel, but all sweeping and dusting are accomplished by a system of vacuum pumps installed in the engine room. These pumps are connected with a complete system of piping which extends throughout the entire building with an outlet in each room and corridor. To these outlets is attached a flexible hose which is equipped with various shaped nozzles. To clean carpets and rugs, an elongated flat nozzle is used and when the valve is opened a strong suction is brought into play and as the instrument is passed over carpet and rug, the dust is immediately withdrawn. The silken wall draperies and carved woodwork are also cleaned in the same manner. Thus the prevention of dust from entering the building with the air, the windows always being closed, and the extraction of any dirt that may otherwise enter, render the atmosphere in the St. Regis as pure as ozone.

The construction of the hotel is of fireproof steel frame type, the floors where covered with carpet being concrete and where exposed to view, marble or tile. The window sashes and frames are of metal, the bath-rooms, elevator shafts, service stairways and service pantries are of tile and all metal work is of bronze. The plumbing throughout is of the most expensive character, all pipe being brass and tinned. It is said that the cost of the plumbing alone would be sufficient to pay for an ordinary hotel of the same size as the St. Regis.

Below the ground floor there are two stories, known as the basement and sub-basement, the engine room, boiler room and pump room being located in the sub-basement. The boiler plant consists of four Heine boilers of 375 horse power, each containing 203 tubes and 60 square feet of grate surface. They are equipped with Tread-kill rocking grates, brass feed gauge and water column lines, quick-closing gauge cocks and two pop-safety valves. Buckwheat No. 2 anthracite coal is used for fuel, which is hand fired. The coal is dumped from pavement above to coal cellar where it is trollied in buckets to boiler room, each bucket being weighed before dumping. A storage capacity of 700 tons of coal is kept under sidewalk. The ashes are lifted by hand, shoveled in buckets and conveyed to street by ash-lift.

The boiler feed-water comes from the city mains and after passing through a Worthington meter, it is filtered and used



Engine Room at the St. Regis Hotel, showing the Four-Valve Harrisburg Engines driving Western Electric Dynamos

for condensing purposes in ammonia condenser and in steam condenser for ice system. It then flows into a return tank, then through a Ward upright boiler feed-water filter, at which the temperature is about 180 degrees, then through a Berryman upright heater and through a Worthington hot water heater to boiler. An auxiliary boiler feed can also be used, the feed line being connected to the hot water house system, which is always under 150 pounds pressure.

There are five Worthington feed pumps, two of which 7½" x 5" x 6" duplex, are connected to main heating return tank, two more 7½" x 5" x 6" duplex pumps are connected to basement heating return tank and one 6" x 4" x 6" pump is connected to high-pressure drip tank. All these pumps force their various supply water through one line into the feed-water heater and then into boiler. In case of emergencies, three of the pumps are connected to house supply tank located on engine room floor. Two Penberthy injectors are connected to fire line, which is always under 150 pounds pressure.

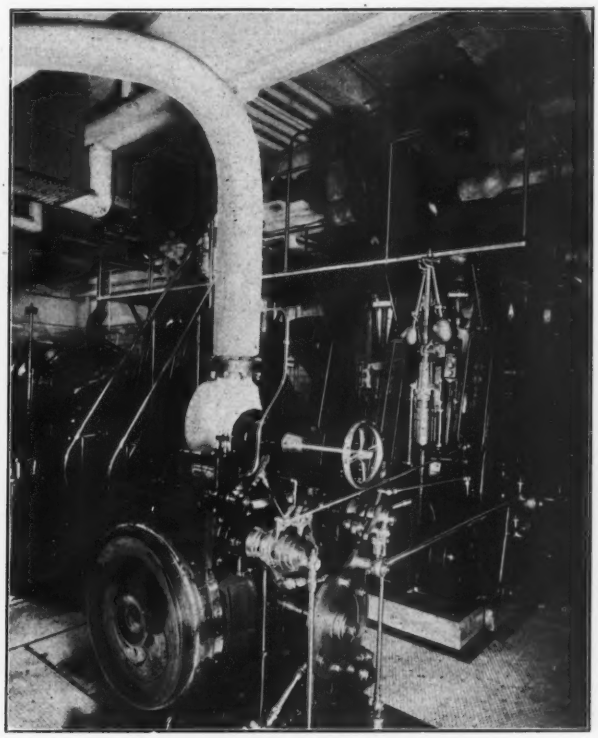
The working pressure of the boilers is 115 pounds per square inch. The steam from the boilers goes into an 8-inch pipe and each two boilers are connected by means of a 12-inch header, which in turn is connected to a main 22-inch header. From this header, one 12-inch line supplies the four generating engines; one 8-inch line supplies the ice machines and brine circulating pumps; one 8-inch line supplies the elevator pumps, fire pumps, the two house service pumps, the two vacuum machines, the two air compressors for pneumatic tube system; one 6-inch main for kitchen, laundry and humidifier; one 7-inch main goes to low-pressure heater for heating system. All these lines are interconnected and by-passed, so that if anything should happen to one line the other line can be used for supply.

The blow-off tanks are situated in the pump room and are connected to two 7½" x 5" x 6" Worthington duplex pumps, which are also used for pumping out sump pit which is located under fire room floor. The sump pit takes care of all drainage water in engine and boiler room. All the other drains from kitchen and toilets in basement and sub-basement empty into eight Ellis sewage ejectors, which are emptied by compressed air supplied by Westinghouse locomotive air compressors. The exhaust drips from engines and pumps flow into a low-pressure drip tank, which is emptied into the sewer whenever necessary by a 6" x 4" x 6" duplex pump.

The engine room contains four generating engines consisting of two 25" x 25" Harrisburg four-valve simple engines running at 150 revolutions per minute and two 20" x 20" engines of the same type, running at 200 revolutions per minute. They are directly connected to Western Electric multipolar direct-current generators supplying current at 120 volts, the two larger generators are rated at 300 kilowatts with a full load current of 2500 amperes and the two smaller generators have a rating of 200 kilowatts, which is equivalent to a full load current of 1666 amperes.

The engines are supplied with steam from a 12-inch main which runs in ducts under engine room floor and from ducts to engines by means of well-rounded bends, a Cochrane separator being connected to each engine line above the trench. Exhaust steam from the engine goes into a 14-inch return main running through same duct to a muffler tank; from there it goes to a branch connection, one branch going to atmosphere on which there is a Crane back-pressure valve, the other branch going to low-pressure header for the heating system.

The engines are equipped with Rochester force feed lubricators, Keystone grease cups on valve gear and Albany grease cups on governors. The eccentrics are fed from oiling system, which is run by air pressure. In connection with the oiling system are seven oil supply tanks situated in the machine shop on one side of the engine room. These oil tanks consist of one tank for machine oil, one for cylinder oil, one for kerosene, one for liquid base oil for refrigerating machines, two for filtered machine oil and one for filtered cylinder oil. From these oil tanks, one special line from machine oil tanks runs directly to engines, while the other lines go to an oil cabinet in engine room, from where it is distributed. The machine oil used in engines is filtered as follows: Two preliminary filter tanks are connected in series, one above the other, which contain cheese-cloth. The dirty oil is poured



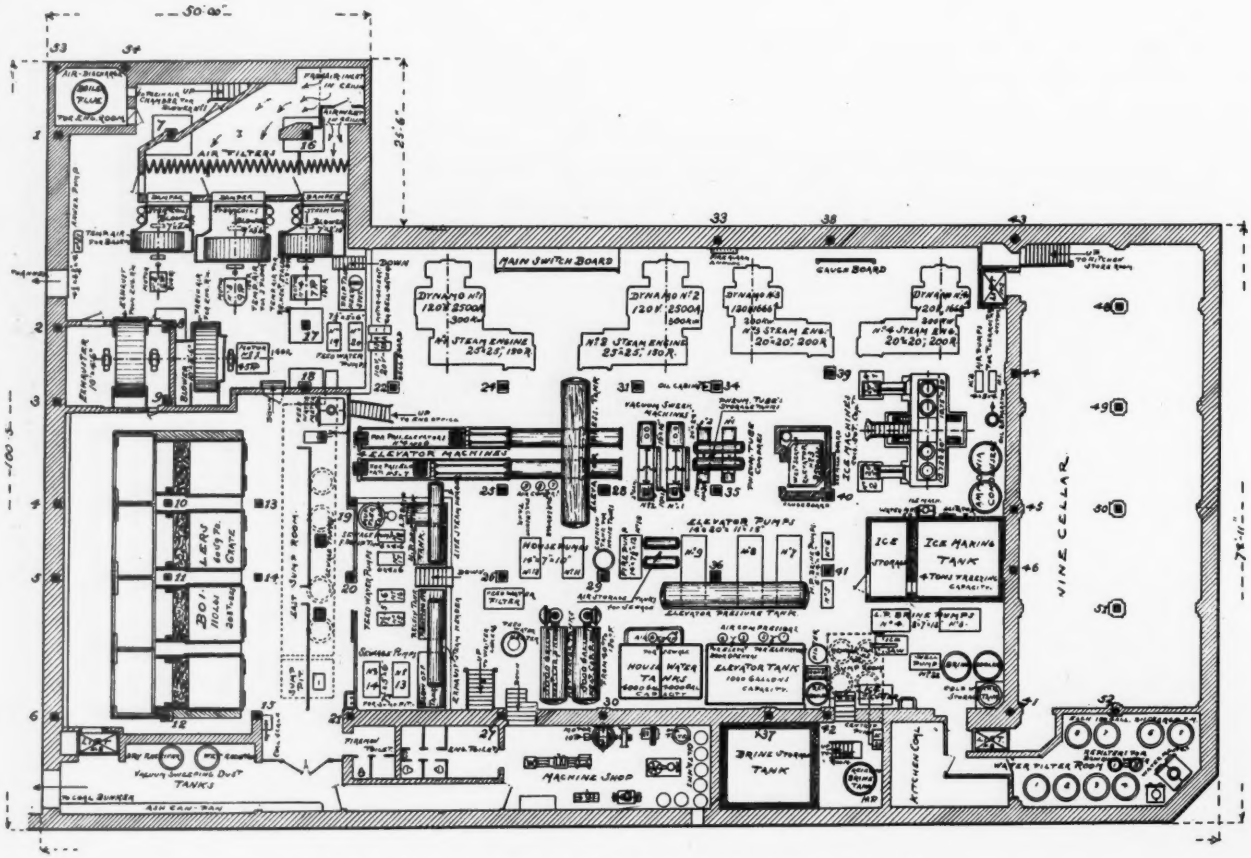
Refrigerating Engines in the St. Regis Hotel.

into the upper one and flows through both by gravity and then into an oil filter of the Burt type, from which it flows into one of the two machine oil tanks. When nearly full, compressed air is turned on and the filtered oil is forced through bearings, by way of the oil cabinet, into drip wells below engine, where it is caught and returned to filter as before. The cylinder oil from the engines is extracted by means of a skimmer from the exhaust drip tank and poured into two preliminary cheese-cloth filters, from which it flows by gravity to a boiling tank in which the oil is boiled. It is then refiltered and is not used again in the engines but is used on auxiliary machinery where heavy oil is required.

Near the generating engines are located two De La Vergne 50-ton ice machines of the horizontal, vertical type. The horizontal Corliss 20" x 20" engine drives the 10¾" x 20" vertical duplex ammonia compressors. After compression, the am-

monia goes to two ammonia condensers and then to expansion valves. Three expansion lines are used, one going to the brine coolers, one to the carafe freezers and one to the 4-ton ice tank located on engine room floor. There are two systems of brine distribution, high and low. The low-pressure brine supplies all the refrigerating boxes on the lower floor, while the high-pressure brine is used to supply cold to the pantry boxes on the 15 floors between the second and the Ice cream is frozen in a tank of brine, the can containing the cream being agitated and revolved by a motor. The ice is frozen in the carafes for table use by being placed in the carafe freezer, which is surrounded with ammonia coils and is kept at 10 degrees.

All water used for ice is distilled and is obtained by condensing the exhaust from the compressors. The steam is condensed, the water reboiled and skimmed, then goes to cooler,



Plan of Engine Room at the St. Regis Hotel showing location of Machinery.

eighteenth. The high-pressure brine is handled by two 6″ x 4″ x 6″ Warren duplex pumps and the low-pressure brine system by two 8″ x 7″ x 12″ Warren duplex pumps.

There are about twenty-five refrigerator boxes on the basement floor, used for various purposes. There are several meat boxes which are kept at 36 degrees, two vegetable boxes kept at 36 degrees, one fish box kept at 20 degrees, three ice cream boxes kept at 10 degrees, one pastry box, two fruit and salad boxes and one box for milk, all kept at 36 degrees, one box for champagne, which is kept at 25 degrees, one for wine at 36 degrees, one for ale and beer at 36 degrees and various other refrigerating boxes for cooling plates, for ready-to-serve dishes, for bakers' use, for goods just received and for garbage.

The ice tank has 4-tons capacity and freezes cakes of 150 pounds each, the brine being agitated by a motor. The ice is harvested by a hand crane and is dumped into a storage room of 8-tons capacity. This ice when used for the table is cut in small two-inch cubes by an ice saw run by a motor. For other purposes it is crushed by an ice crusher, also run by a motor. after which it passes through a charcoal filter into a storage tank. An automatic filler is used for filling the ice cans.

There are 16 elevators in the building, of which four are passenger, two are service, seven are used for dumbwaiters, two are sidewalk lifts and one is used for wine lift. The four passenger elevators are of the horizontal Otis hydraulic type and have a lift of 242 feet. The two service elevators are of the vertical Otis hydraulic type, and have 275 feet lift. The dumbwaiters are the Burdette-Rowntree electric type and have a lift of 250 feet. The two sidewalk lifts which operate between the sub-basement floor and sidewalk are of the hydraulic plunger type and have a lift of 40 feet. The wine lift is of the same type, with 25 feet lift.

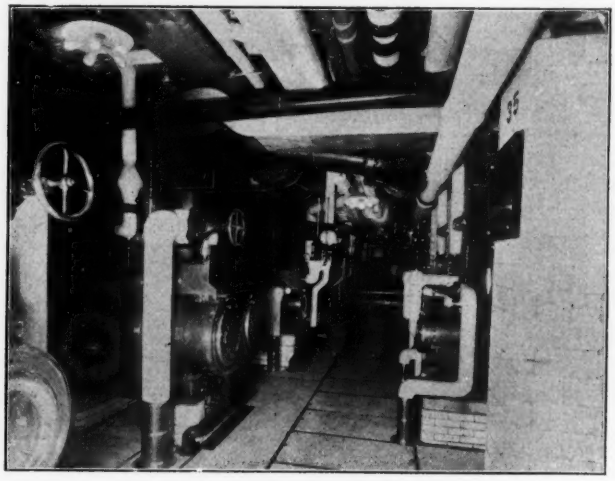
The elevator pumps are three in number and operate at 165 pounds water pressure. They are Worthington compound duplex, 14″ x 20″ x 11″ x 15″ and are controlled by Foster valves, as are all the other pumps throughout the building. The pumps receive their water supply from a 10,000 gallon surge tank on engine room floor and pump it into a pressure

tank, 18 feet long by 5 feet in diameter, which is situated over the pumps; from there it goes into a distributing tank located over elevator cylinders. This latter tank is connected to another tank of twice the capacity, which is situated on roof and which acts as an accumulator. The water from elevator cylinders is then returned back to surge tanks, completing the circuit. Two Westinghouse air compressors are located on side of the surge tank and are used to supply compressed air to elevator system to prevent water hammer.

The dumbwaiters are run by electric motors and are used between kitchen and pantries on the different floors. They are entirely automatic in their operation. The attendant in kitchen sets the starting switch and by pressing a button corresponding in number to the floor where the waiter is desired, it stops at that floor. When the doors of elevator are open, the circuit is broken and the waiter cannot be moved until they are closed. The opening and closing of the doors is indicated in the kitchen by a light.

The Miles pneumatic tube system is used for transmitting messages throughout the house, there being two central stations, one in the office for guests, the other in kitchen for pantry service. Each floor is therefore connected with the office by means of a pneumatic tube for transmitting messages for guests and with the kitchen for transmitting orders for meals. Two Miles compressors are used, 24" x 24" air end, 10" x 24" steam end. They pump into a pressure tank at 15 pounds pressure, the pressure being reduced by means of an expansion valve to 2½ pounds, which is the working pressure of the system.

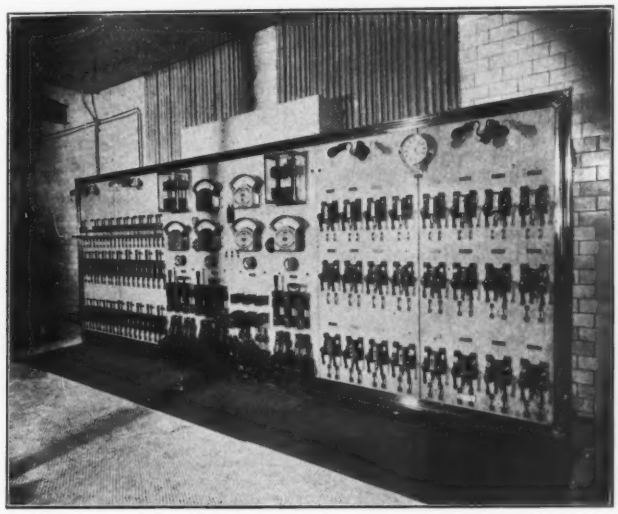
For cleaning the halls, walls, carpets and curtains, Kenney's Vacuum system is used. The system is operated by two Kenney vacuum machines, 15" x 15" air end, 10" x 15" steam end, made by the Clayton Air Compressor Co. The air, being



A few of the 23 Pumps in the St. Regis Hotel.

drawn through the sweeping nozzles, is passed through two separating tanks, a dry and a wet tank. The dry tank removes most of the dirt and if any should remain it is passed through a body of water in the wet tank.

Notwithstanding the fact that the St. Regis is fireproof, there are fire alarms located on each floor, which ring up not only the general office of the hotel, but the office of chief engineer. From the fire alarm station in the engine room, all the floor can be notified of an alarm or only one floor, as desired. The fire department can be notified on every floor or from the engine room. Connected to the fire mains is a regulation Worthington fire pump, 14" x 7½" x 12", which is always under water pressure and steam pressure.



The beautiful Switchboard at the St. Regis Hotel.

For supplying the house with service water, two 14" x 7" x 10" Worthington pumps are used. From the house tank of 8000 gallons capacity, located on the engine room floor, the water is pumped through a cushioning tank and from there to a large header. From the header one line goes to the hot-water generators and the others distribute throughout the building, all of them being connected to overflow tanks on roof. These service pumps are regulated with Ford governors.

All the water entering the building, no matter for what purpose used, is passed through eight Loomis-Manning filters. The drinking water is again filtered through two special porcelain-lined filters. In order that there shall never be any scarcity of water supply, two 4-inch and one 6-inch line are used, each being connected to different city mains. Each line is equipped with a Worthington meter.

The Wolff system of heating and ventilating has been worked out on a plan which is very elaborate. All the heating in the building is indirect, except the servants' quarters on the 18th floor. The systems of blowers in sub-basement, on third, seventh and twelfth floors, take in air from the outside through filtering screens. The air is then passed through steam coils and across humidifiers and into ducts for distribution. The fans on the third, seventh and twelfth floors are duplicates. There are two fans on each floor, each directly driven by two duplicate 14 horse power motors, so that in case of accident to one motor, the other motor can be used to supply power.

The engine room is ventilated by two 10-foot fans driven by one 40 horse power motor, one of the fans bringing fresh air in and the other one driving the hot air out. The kitchens are ventilated by a 7-foot blower driven by a 7 horse power motor. The first floor is supplied with tempered air by a 9-foot blower driven by a 9 horse power motor and one 7 horse power, 7-foot blower supplies a portion of the first and the second floor with tempered air.

All the exhaust ducts are connected to exhaust fans located

on the 18th floor. Three 6 horse power motors driving 8-foot fans are used for room exhausts, one 8 horse power motor driving a 9-foot fan being used for open fireplace exhausts and one 8 horse power 9-foot fan is used for kitchen exhaust.

The 19th story contains the elevator pressure tanks, cold, hot and flushing tanks, storage batteries for bell and annunciator system and tailor shop, sewing rooms, printing shop and carpenter shop.

The electric load on the generators consists of 10,000 incandescent lamps, electric heaters, electric curling irons and 32 motors. The mains from the four generators lead to the switchboard through conduits. The switchboard is built of beautiful marble in five panels. The centre panels are the generating panels and contain four ammeters, a station voltmeter, a bus volt meter, two recording watt meters, one for power load and one for the lighting load. The power panels are to the right and contain 24 circuit breakers. The lighting panels are on the left and contain 31 distributing switches.

It must not be thought that because everything throughout the hotel is built on such an expensive scale, the system of operation is carried along the same lines. The reverse of this is true, as the engineering department is a model of economy and efficiency. Every drop of energy from the coal pile to its utilization is tracked carefully by means of recording instruments, and the efficiency and cost of operation of the plant are known for any time. Not only is every pound of coal weighed, every pound of water metered and every kilowatt of energy generated recorded, but all the oil used is carefully measured and every pressure and temperature throughout the mechanical plant are known at any minute. Mr. J. C. Jurgensen is chief engineer and Adam Harkness is the first assistant of this very expensive but highly-economical plant.

THE HEATING OF ENGINE BEARINGS

By R. T. Strohm.

One of the most prolific of the various sources of trouble in and about the steam engine is a hot bearing. It is liable to occur at any odd moment during the operation of the engine, and its cause is often a difficult matter to determine, while the manner of remedying the defect is likewise a point of considerable and urgent importance. For, there is many a power plant, especially among those of small size, in which there is but a single power unit, and any interruption in the operation of that unit necessarily means a stoppage of work in the mill or factory deriving its motive power from the afflicted engine. This halt, or shut-down, as it is more familiarly termed, means an actual loss in dollars and cents, the amount depending upon the length of the stop and the character of the output of the shop. It occasions no surprise, therefore, to learn that engineers unanimously detest the idea of a hot bearing with its subsequent trouble and labor.

If an engine has been running along smoothly for a long period, and then, without warning or apparent reason, develops a hot bearing, the first thing that the engineer thinks about—after he has hustled around and succeeded in keeping the engine turning over—is the cause of the difficulty.

Assuming that the engine has previously been doing satisfactory work, there are two general causes, either or both of which may be at the bottom of the trouble. First, it may be the fault of the engine; and secondly, it may be the fault of the lubrication, or, both may be to blame.

The location of the hot bearing should give some slight clue as to the reason for the heating, though this is by no means an inflexible rule. However, the various causes of hot bearings have been observed, and while there may be others as yet undiscovered, it may help engineers somewhat to learn of the many ways in which this trouble may present itself.

First, let the causes originating in the engine mechanism itself be taken up and discussed. The one that naturally presents itself to the mind is bad alignment of the engine, due to the dislocation or slight displacement of some part. The engine may get out of line through a number of causes. The frame or bedplate of the engine may spring or bend; the foundations of the engine may settle unevenly and so throw the parts out of line; the main bearing may wear down and lower one end of the shaft; or the pedestal or pillow block may move somewhat.

If the bedplate is sprung out of line, there will doubtless be trouble at the crosshead. For, in that case, the crosshead would bind in its guides, and if this binding were pronounced, there would be heating. The same defect would also be very likely to cause trouble at the crankpin. For the wristpin end of the connecting-rod would be moved out of line, with the result that the crankpin end would also be slightly disturbed, and the brasses at that end would not bear squarely on the pin.

The condition of affairs that would be brought about at the crankpin end is shown in Fig. 1. Owing to the twisting of the connecting-rod, the brasses touch the pin on their edges and at opposite sides, while the other edges are in contact with the pin when the crank has moved through half a revolution. As a result of this imperfect bearing upon the pin, a very small part of the bearing surface of the brasses is forced to take the entire thrust or pull in the connecting-rod, and heating follows as a natural consequence.

To remedy this, one of two things may be done. If the engine is not very much out of line, it may be possible to scrape the bearings down at the high points, so that they touch the pin throughout its whole length and thus distribute the pressure to better advantage, over the area of the journal. This is only a makeshift arrangement, however, and if heating still continues, there remains simply the other alternation, which is to take down the parts and line up the engine and set each part in its proper relation to the others.

If the foundations are properly designed and constructed, there will be little likelihood of trouble because of their settling unevenly. However, if this does occur, it will bring about the same state of affairs as that already shown in Fig. 1. There is at least one class of engines which is free from the possibility of distortion in this way. It is the straight-line engine, and the freedom from mis-alignment is obtained by having only three supports for the entire engine; one for each of the

main bearings, and one for the cylinder, the engine being a centre-crank engine. If the foundation settles, though, the engine should be lined up at once, and steps should be taken to prevent any further settling.

The gradual wearing down of the main bearings may throw the parts out of alignment, especially when one wears to a greater extent than the other. Most engines are fitted with adjustable bearings at the shaft, and these can be set up so as to bring the centre line of the main shaft into the horizontal plane through the centre line of the cylinder.

Movement of the pedestal, which occurs in a horizontal plane, will also throw the pressure on the edges of the crankpin brasses. However, the pillow-block is likewise made adjustable, so that in case it is displaced it may be set back again and the engine correctly aligned without much difficulty.

Heating due to faults in the lubrication may arise in a number of ways. One of the most common causes is dirt or grit in the bearing. This may be introduced with the oil, or it may work its way into the bearing from the surrounding air. In either case the result will be heating. In a bearing properly lubricated, the oil forms a very thin film, or sheet, between the surfaces of the journal and of the brasses, holding them apart, so that there is little actual contact of metal with metal. As soon as dust and grit get into the bearing, they destroy this film at many points, so that the polished metal surfaces may touch each other, and therefore greater friction and wear are developed. Friction is always accompanied by the generation of heat, and this heating, if rapid or continued, will bring disaster.

Furthermore, in most bearings it is the practice to have the journal of a harder metal than the seats. The seats are usually of Babbitt, brass, or antifriction metal, so that they will wear the faster, and thus obviate the necessity of frequently replacing a worn journal with a new one, which would be far more expensive than the renewing of brasses. Now, when dust and grit get into a bearing, the harder particles become firmly imbedded in the soft seats, and then the seats act precisely like pieces of sandpaper or emery cloth, though, of course, less violently. But the final result is the same. Before long, the surface of the journal becomes scored and cut, and this roughness, reacting upon the brasses, tends to cut them, with the result that a hot bearing soon develops.

If it is found that hot bearings are due to the dust that drifts into the engine room, then especial care should be taken with the lubricating devices. It should be seen to that no oil cups are left open at the top, that all open oil holes are protected by wads of waste, or closed by pegs during the operation of the engine. If the grit enters through the oil supply, then a plain heart-to-heart talk with the oil dealer, and a change in the quality of the oil, should bring about more satisfactory conditions.

There is always a chance that the oil may not be suited to its work, even though it be quite pure and clean. For example, it may be too light, that is, too thin, for the purpose for which it is used. In any bearing, the lubricant used must possess sufficient body to enable it to stay between the moving surfaces. If it is too thin it will be squeezed out under the pressure existing between the bearing surfaces, and metal to metal contact, with consequent heating, will follow. The fitness of an oil in this respect is a matter to be determined by actual trial for each specified case.

But even assuming that the oil is of the proper grade and quality, the bearing must have a continuous supply, and this supply must be of sufficient amount to maintain a cool-running bearing. Hot bearings have resulted from a partial or from a total stoppage of the oil supply, due to the filling up of the oil channels and holes or the emptying of the oil cups. If a gummy oil is used, clogging of the oil passages is very likely to occur. Cases are on record in which a single night was sufficient time for the oil channels of an engine to become gummed up so as to prevent oil from flowing. Should this occur, clean out the bearings and the oil grooves with kerosene, and then use a new grade of oil. It is not hard to test an oil to see whether it will grow gummy. Simply place a few drops on a clean plate of glass and allow the whole to stand in a warm, dry place for a few hours. Then observe whether the oil remains fluid, as before, or whether it has hardened into viscous lumps, like drops of pitch.

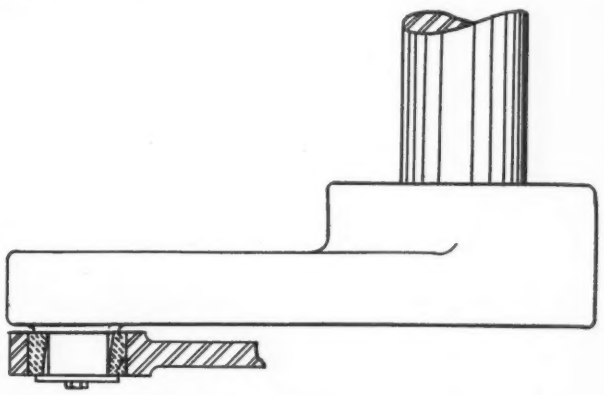


Fig. 1.

Hot bearings caused by complete failure of the oil supply must be attributed to lack of care on the part of the engineer or of the oiler. In the smaller plants, the engineer alone is responsible for the condition of the entire steam plant. In the larger plants, however, there are oilers whose sole duty it is to see that the oil cups are kept full, that each oiling device is operating as it should, and that each bearing is running cool. Frequent and regular rounds of the engine are made, observing the rate of feed at different points and feeling the main bearings, the crankpin and so on, to determine their temperatures.

There are many other things which may cause hot bearings, some of which are faults of design, though these are rare. For instance, too small a crankpin, or too small a main journal will cause overheating. In the design of bearings, it is usual to allow a certain maximum pressure to each square inch of projected area, the projected area being the product of the diameter and length of the journal. If this maximum pressure is taken too large, the load on the bearing will be excessive and the consequence will be heating.

Or, it is possible that the conditions of loading of the engine may produce a hot bearing. Take, for example, an engine installed in a factory which has been enlarged, from time to time, without increasing the size of the power plant. In this case, additional power is secured by raising the boiler pressure, by speeding up the engine, and by making the point of cut-off later. The result is that the engine is finally doing perhaps 50 or 100 per cent. more work than at first. That is, its normal

loading has been increased far beyond the point for which it was designed to work economically. Under such conditions the engine is said to be overloaded, and the pressures upon the bearings may become excessive, resulting in heating, because the bearing pressure per square inch has been increased beyond the point of safety. The remedy for this state of affairs is to get a larger engine for the work, or else to install another unit to carry the increase of load.

Every engine needs to be overhauled and repaired at certain times, and at these times the bearings come in for a large share of attention. It is frequently necessary to fit new brasses to replace those badly worn, and hot bearings may develop after one of these overhaulings. This is often due to the relative condition of the surfaces in the bearing. When a new brass is scraped and fitted, it may be, to all appearances, very smooth and accurate. But it takes a little while for the journal and the newly-fitted brass to become accustomed to each other, so to speak. Consequently, if the new brass is set up just the same as the old one, there is liable to be trouble, whereas, if it be left so that the journal has just a little play, for a short time, it will be found that it can eventually be set up properly without any ill-effects.

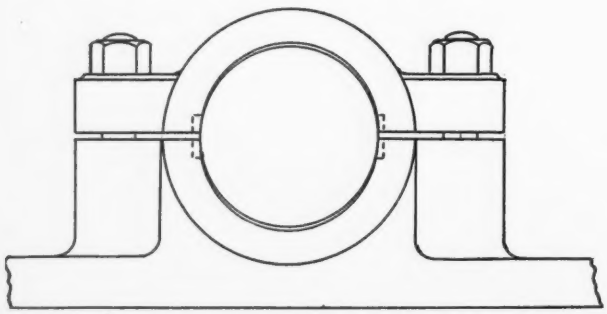


Fig. 2.

Then, again, there is the engineer who is forever using the monkey-wrench, tightening a bolt wherever he finds a suspicion of slackness. He may be the cause of bearings running hot, through undue tightening of the brasses upon the pin or upon the shaft. Drawing up the brasses against the journal in this fashion simply increases the pressure per square inch of projected area, and likewise helps to squeeze out the lubricant, both of which are causes of heating.

In fitting brasses to a journal, care should be observed so that here is no binding or cramping at any point. Sometimes, through error in construction of the brasses, or through their warping under the effects of heat, the edges of the boxes bind upon the pin, as shown, exaggerated, in Fig. 2. These edges, bearing hard against the journal, tend to scrape off the lubricant, and this, combined with the pressure and friction, brings on undesirable results. The remedy is to scrape the edges down, or else to cut them away for a short distance on each side, as indicated by the dotted lines.

In the opening paragraphs of this article it was stated that considerable loss might result from even a shut-down of short duration. Consequently, it is frequently desired to keep the engine running at its normal speed, in spite of a hot bearing, until a convenient time for stopping the engine arrives. To do this, the hot bearing must be instantly cared for and continually watched. The best method is to flood the bearing with some cooling lubricant. There are a number of these, all of which have been tried and found useful. One consists of a mixture of oil and graphite, the graphite having a sort of smoothing effect, in filling up the cuts in the bearing surfaces and thus preventing further abrasion. The same result has been obtained by the use of soapstone, mica, or sulphur, in combination with lubricating oil.

If, however, the bearing fails to respond to treatment of this kind, and the heating still increases, then there remains but one thing to do, which is to shut down. Failure to do so may result in serious accident. If the bearing is a Babbitted bearing, the metal may melt under the effect of heat, and this means additional trouble. If the brasses are solid, they may warp and crack and aside from being rendered worthless themselves, they may so cut and score the journal as to necessitate costly repairs.

Or, the brasses may suddenly seize the journal. At least one instance of this kind has occurred. The crankpin of an engine heated and the brasses seized so firmly to the pin that the connecting-rod was bent to a right angle at the narrow portion nearest the crankpin. This resulted in shortening the distance between the centre of the crankpin and the centre of the crosshead pin, so that the piston struck the crank end of the cylinder and the main shaft bearing was torn loose, the entire engine being more or less damaged.

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Approximate Rule for Finding Area of Segment.

An approximate formula for finding the area of a segment of a circle when the cord and height are given, is as follows: Let h = height of segment, and a the cord, then

$$\text{area of segment} = \frac{4h^2}{3}\sqrt{\frac{a^2}{4h^2}} + .392.$$

The rule is, divide the square of the cord by 4 times the height of the segment; add .392 to the quotient and find the square root of this sum. Multiply this root by $^4/_3$ of the square of the height of the segment and the product will be the approximate area of the segment correct to three figures.

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Reinforcing Ring for Manholes.

EDITOR THE PRACTICAL ENGINEER:

In your October issue, A. W. B. E. asks for rule for figuring width of reinforcing ring for manholes in boilers. The rule is as follows: Square the short diameter of the hole and add to it six times the short diameter multiplied by the long diameter and add the long diameter. Extract the square root of this sum. From this root, subtract the sum of the short diameter plus the long diameter and divide the remainder by 4. The result will be the width of the ring.

Crawford, N. J. W. H. F.

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Foaming in boilers is caused by dirty water, trying to evaporate more water than the size and construction of the boiler is intended for, taking the steam too low down, insufficient steam room, imperfect construction of boiler, main steam pipe too small and by carrying the water line too high.

LATEST TYPES OF AMERICAN STEAM ENGINES

Chandler & Taylor High-Speed Engines

The growth of the high-speed engine has been very rapid in this country, especially in the field of direct-connected electrical service, where the demands often require a heavy compact engine capable of being operated at high speeds. Since in electrical service it is very important that engine builders and generator builders should have some general standards for direct-connected units, a committee of the American Institute of Electrical Engineers issued a report of this subject, which report is now being followed by the leading engine and generator builders in this country.

The engines built by the Chandler and Taylor Co., of Indianapolis, Ind., are the first to be built in accordance with the recommendations of this joint committee as to speeds, sizes of units and sizes of shaft, so that all their high-speed engines will readily match the corresponding size of any generator which has been built according to the recommendations of this committee. The importance of this is very obvious both from a mechanical and an operating standpoint.

Another distinctive feature of this type of engine is the manner in which the adjustments for the crank shaft bearings are made. In designing the bearings for an engine, directly connected to an electric generator, it is absolutely essential that the shaft be kept from shifting sidewise as the shaft journal wears. The armature which is carried by the shaft must at all times be kept in the centre of the magnetic field of the generator. Any unbalanced condition not only causes sparking at the commutator, but also causes a side pull on the shaft which might result in springing the shaft or injuring it otherwise. The bearings have been designed specially to meet these conditions and the bearing next to the crank disc is patented and used on those engines only.

The construction of the bearings, shown in Figs. 2 and 3, is such that the Babbitt metal surrounding the shaft is compressed against the shaft from all sides with equal pressure, which always maintains the centre line of the shaft in the same position. The Babbitt lining of the bearing is made of two

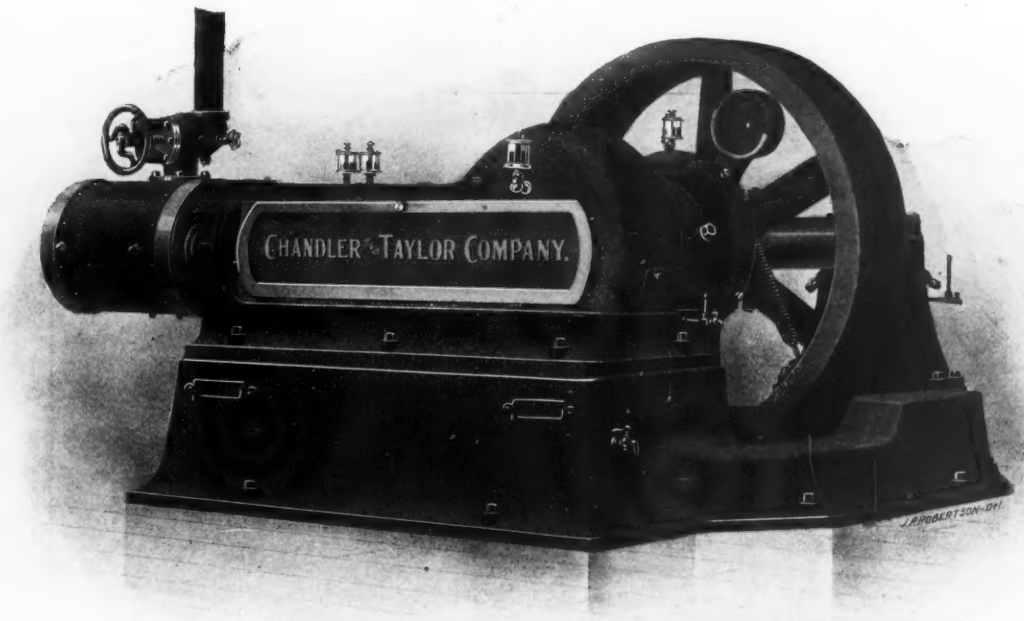


Fig 1.—Front View of Simple Direct Connected Engine.

The front view of the simple direct-connected engine is shown in Fig. 1, and while it is entirely enclosed, so that the engine will not throw oil, it is at the same time accessible for inspection and adjustment. The oil guard can be easily removed and the long name plate can be removed by taking out the thumb screw at the top and lifting the whole plate off the hinges which support it. If only a partial inspection is desired, the plate can be opened on these hinges and held in position by a light chain which is provided to keep it from dropping.

equal truncated cones, meeting at their larger bases, each of them being split lengthwise into two equal parts. These cone-shaped Babbitt shells are corrugated on the outside, parallel with the shaft. As these Babbitt shells are split lengthwise, it will be seen that they can be compressed around the shaft and fitted to it by the tapered cast-iron rings which hold them in place. These cast-iron rings are drawn upon the tapered part of the Babbitt shell by means of an outside screw ring, which draws the two cast-iron rings toward each other along

the shaft, which compresses the Babbitt metal. Dowel pins in the main frame of the engine prevent the shells from rotating with the shaft. A groove is cast in each Babbitt shell for the purpose of giving room for an oil chain, which runs over the shaft and carries oil up from the reservoir in the frame of the engine below the bearing. The bearing is locked in place by tightening the bolts holding the cap to the frame.

In order to take up the wear on the bearing, it is only necessary after loosening the four bolts holding the cap to the frame, to insert a bar through the hole provided in the cap and with this bar turn the screw rings so as to draw the cast-iron shells toward each other on the cone-shaped Babbitt shells.

The crosshead is a heavy casting of steel. The piston rod is screwed into it and held in place by a heavy lock nut. The shoes are wedge-shaped, the wear being taken up by sliding the one wedge upon a similar wedge on the crosshead, stud bolts being provided for the purpose.

The connecting rod is a solid steel forging, morticed out at each end for the reception of the boxes. The crosshead end is provided with a bronze box, and the crank end with a brass box, Babbitt lined. Both boxes are provided with wedge and screw take-up for the wear.

known Rites type. In order, however, not to effect the isochronism of the governor, the inertia weight is designed to eliminate cross balance in the governor, which is effected by keeping the centre of gravity of the two ends in a line perpendicular to the centre of the governor pin.

The Chandler and Taylor compound engines are built on the tandem plan with the low-pressure cylinder outside the high. The principal features of this type are simplicity, ease of repair and a special form of valve gear which always maintains a constant steam pressure in the receiver. With this gear, the high-pressure valve is wholly under the control of the governor and the cut-off is varied to suit the load. The low-pressure valve is partially under the control of the governor and partially under the control of the fixed eccentric and just enough under the control of each to vary the cut-off of the valve for different loads in such a manner as to maintain the pressure in the receiver constant under all loads within the capacity of the engine, which results in an equal division of the total load between the two cylinders.

The arrangement of rocker-arm, eccentric rods, link and valve rods is shown in Fig. 4. The rocker-arm, A, is attached to the high-pressure eccentric rod, B, which is under the con-

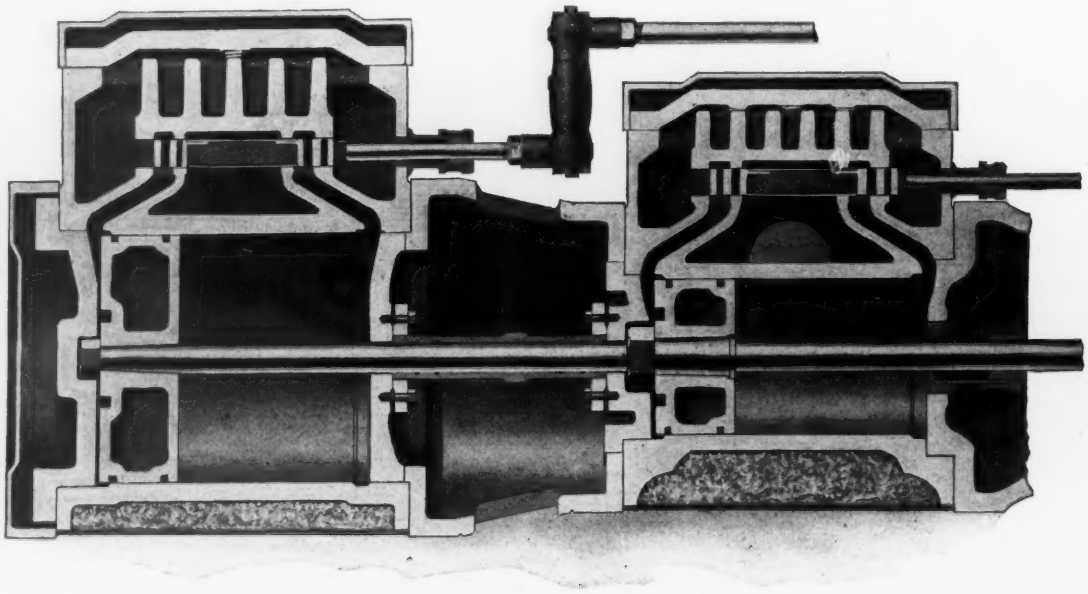


Fig. 5.—Sectional View of the Compound Cylinders.

The valves are of the double-ported box type, and are balanced by heavy-pressure plates, which are held in position by springs pressing against the steam chest cover of the engines. In the event of water coming into the cylinder, the valve and pressure plate can lift away from the seat, giving the necessary relief and preventing breakage. This double-ported principle makes it passible to give large port areas with short valve travel, and also prevents the engine from running at high speeds. The balanced valves allow the generator to move the valve easily and any breakage due to wear can be taken up by scraping down the ledges upon which the pressure plate rests, which can be done without dismantling the engine or disturbing the adjustment of the valve.

The type of governor used on this engine is of the well-

trol of the governor. The low-pressure eccentric rod, C, connected with the eccentric has a fixed travel. The high-pressure valve rod, D, the low-pressure valve rod, E, and the link, F, complete the arrangement. The link, F, is connected to the rocker-arm at its lower end, to the fixed eccentric through the rod, C, at its upper end, and to the low-pressure valve rod near its middle.

It can readily be seen that the top end of the link, F, always has the same length of travel because it is under the control of the fixed eccentric. The bottom end will have a varying travel according to the load because it is under the control of the governor. Anw intermediate point on the link will have a travel more or less due to the governor or the fixed eccentric, as the point may be nearer to the one or the other. At some

intermediate point, the travel of the valve will be such a compromise between the two motions or travels imparted to it by the two eccentrics, that it will give the low-pressure valve just the required amount of travel to keep the pressure in the receiver constant in its relation to the initial pressure in the high-pressure cylinder.

A sectional view of the cylinders showing the valve rods as they come from the rocker-arm is shown in Fig. 5. In this arrangement of cylinders, the low-pressure cylinder overhangs

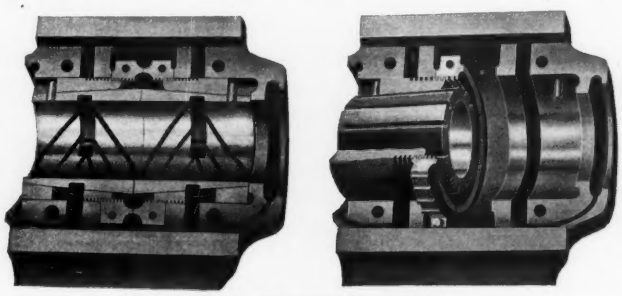


Fig. 2 and 3.—Construction of Bearings.

the distance piece, so that the cylinder heads in the distance piece, together with the piston heads and rods for both cylinders, can be withdrawn through the low-pressure cylinder without disturbing either cylinder or dismantling the working parts. This is accomplished by making the cylinder heads in the distance pieces with lugs cast on them for the studs. Corresponding lugs are cast on the distance piece for the holding of the cylinder heads when the engine is assembled for work. If it is necessary to remove the heads and the pistons, the nuts are

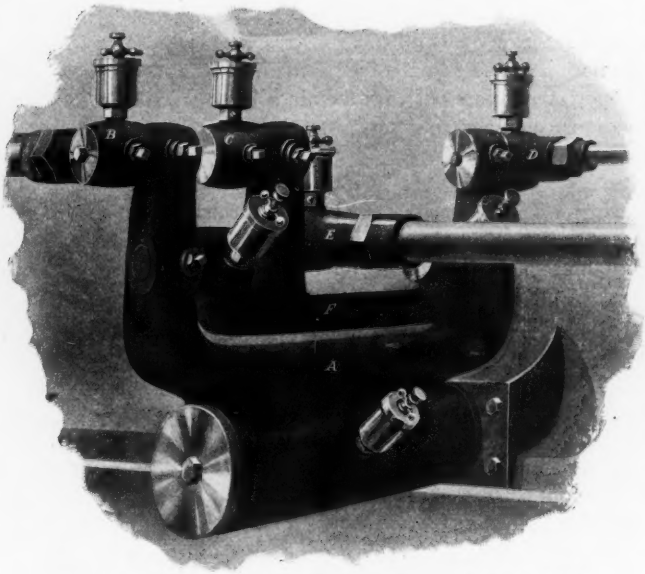


Fig. 4.—Arrangement of Rocker Arm, Eccentric Rods, Link and Valve Rods used on Compound Engine.

unscrewed from the cylinder studs and with a slight turn both heads are free to be withdrawn.

Another feature of the compound engine, as will be noticed in Fig. 5, is the elimination of two stuffing boxes between the cylinders, a close fitting brass sleeve being used instead. This sleeve is finished on the inside and is grooved so that a water packing is formed which prevents any leakage of steam.

Growth of Electric Light and Power Stations.

The Bureau of the Census has just published a report on central electric light and power stations for the year ending June 30, 1902, prepared under the supervision of Mr. W. M. Steuart, chief statistician for manufacturers. It is the third of a series of reports on the operation and utilization of electric current. The statistics do not include isolated electric light and power plants installed in manufacturing establishments, hotels, office buildings, etc., for the purpose of furnishing the light and power primarily for the use of the individuals, firms or corporations operating such establishments.

The growth of this industry is shown by the following figures: From 8 stations beginning operation in 1881 the number rose to 100 in 1886, to 208 in 1889, and to 247 in 1892. During the following years of depression the number of new stations fell; but in 1895, though a time of financial stringency, it again rose to 239. In 1898, it reached 277, or more than the number beginning operation in the entire period from 1881 to 1886, inclusive. The number for 1901 was 250, and for five months of 1902 it was 146. In the twenty years from 1881 to 1901, inclusive, an average of 165 private and municipal stations have begun operation each year. The spread of the agitation for municipal ownership of public service enterprises is illustrated in a somewhat striking manner. Of the 815 municipal stations enumerated, only 68 had been installed up to 1889. In that year 40 were introduced, and in 1895 the number of new stations reached 73, increasing in 1898 to 82. The returns for 1902 indicate that the ratio was fully maintained in the census year.

In 1902 there were in the United States 3620 central electric stations, with a cost of construction and equipment at $504,740,352. Employed were 6996 salaried officials and clerks with salaries amounting to $5,663,580; and 23,330 wage-earners with wages amounting to $14,983,112. The gross income was $85,700,605, comprising $84,186,605 from sale of current and $1,514,000 from other sources. Total expenses were $68,081,375. The total output of stations for the year, in kilowatt-hours, was $2,507,051,115. The number of arc lamps was 385,698 and of incandescent lamps 18,194,044.

Private stations form by far the largest portion of the industry, constituting 77.5 per cent. of the total number of stations in operation during 1902. Their income from sale of current was $78,735,500, or 91.9 per cent. of gross income, the expenses of operation 92.3 per cent. of the total, while they gave employment to 89.4 per cent. of the total number of wage-earners engaged in the industry and paid 90.5 per cent. of the total amount of annual wages. The primary power plant equipment of these stations formed 91.3 per cent. of the total horse power of all stations, while the generating equipment formed 90.6 per cent. of the total horse power of all dynamos. The kilowatt-hour output of private stations formed 92.2 per cent. of the total, and the arc lamps in such stations formed 86.8 per cent. of the total number wired for operation.

The largest number of stations was in Illinois, followed by Pennsylvania, New York, Ohio, Michigan, Indiana, Iowa and Wisconsin in the order named. No other State reached the 150 mark. The New England States were well supplied with stations. Massachusetts reported the largest number, then came Maine, Vermont, New Hampshire and Connecticut. Among the Southern States, Texas led, with Kentucky, Tennessee and Georgia following. Of the Western States, California reported

the largest number of stations, Colorado, Washington, Oregon and Montana being next in order. Of the 1892 places reported at the Twelfth Census as having a population of 2500 and over, 1511 had one or more central electric lighting stations. Of the places with a smaller population, 1960 had similar stations.

A number of companies supply areas of many square miles in which are located scores of cities, towns, incorporated villages and mere hamlets, all enjoying the benefits of electricity and constituting a source of income for the enterprise. The extreme limit of such work at the time of this report was marked by the long-distance power transmission on the Pacific coast, where current from the Sierras was actually delivered for general consumption in San Francisco and Sausalito, and was also distributed from the same plants over lines which ramify into half the counties of the State of California. The whole aspect of central station current supply in its relation to population has in reality been utterly changed by the development of polyphase power transmission plants. There are at least a thousand such plants, with lines frequently 15 or 20 miles long, in many cases 40 or 50 miles, often 60 or 90 miles, and sometimes even 150 or 200 miles. These transmission enterprises are peculiarly typical of the far Western States, but are by no means concentrated there, being scattered over all the Union.

Private stations expended $40,050,613 and municipal plants $1,741,834 in construction and equipment during the year covered by the report. The total for private stations from their origin until 1902 was $482,719,879, giving an average outlay of $328 per horse power of dynamo capacity. It is interesting to compare these figures with those for municipal stations, which show a cost for construction and equipment of $22,020,473, and an average of about $145 per horse power of generating capacity; it is not safe to accept this average as a basis of comparison, on account of the wide variations revealed in the different States, which range from $114 in Ohio to $844 in the State of Washington.

Although the practice of supplying current for motive power and other uses had grown rapidly, the supplying of current for light was still preponderatingly the business of both private and municipal stations. Of the total income $70,138,147, or 81.8 per cent., was directly derivable from lighting. The private stations obtained 80.5 per cent. and the municipal stations 96.9 per cent. of their income from this source. This income from sale of current for lighting purposes was derived from 385,698 arc lamps and 18,194,044 incandescent lamps. The average income per lamp for arc lights in private stations and used for commercial or other private lighting was $48.88; used for public lighting, $83.20. In municipal stations, for commercial or other private lighting, it was $41.46; for public lighting, $69.98. The incandescent lamps in private stations in commercial use earned an average income of $2.40 per lamp; in public service, $6.06. In municipal stations these lamps earned $1.92 in commercial service and $5.93 in public service.

The total expenses for private and municipal stations were $68,081,375. Of this $20,646,692 was for salaries and wages, $22,915,932 for supplies, materials and fuel, $11,895,206 for rents, taxes, insurance and miscellaneous expenses, and $12,623,545 for interest on bonds.

Physical equipment is considered under the three heads: Power and generating equipment, line construction and service line equipment. The power plant equipment showed 5930 steam engines with 1,379,941 h. p., and 1390 water wheels with 438,472 h. p.; and the generating plant equipment 3823 direct-current, constant-voltage dynamos with 442,446 h. p.; 3589 direct-current, constant-amperage dynamos with 195,531 h. p., and 5122 alternating and polyphase-current dynamos with 987,003 h. p. The line construction had 107,263 miles of mains and 17,880 miles of feeders. For the service line equipment, meters, lamps and motors are the important items. There were 582,698 meters, 575,004 of these were mechanical and 7685 chemical. The aggregate of arc lamps of all classes was 385,698, of which 334,993, or 86.8 per cent., were operated from private stations and 50,795, or 13.2 per cent., from municipal stations. In addition to these 385,698 arc lamps connected to the circuits of central stations, the street railways operating electric lighting stations reported 33,863 arcs, making the total for the United States 419,561.

The average output in kilowatt-hours per day for all stations was 6,960,783, making a total for the year of 2,507,051,115. For private stations the output was 2,311,146,676 kilowatt-hours, and for municipal stations 195,904,439. Among the private stations, the totals for New York are at the head of the list; among the municipal, Illinois.

Cylinder Lubrication of Air Compressors.

In lubricating the interior of an air compressor cylinder, the existing conditions are different from those found in a steam engine cylinder. In the latter, moisture is always present and has a tendency to wash the oil from the surfaces. In the compressor cylinder, the heat is dry and the oil adheres to the surfaces better and longer, so that less oil is required than in a steam cylinder. Owing to the more intense dry heat, however, to which the oil is subjected, it must be of such a nature that it will not volatilize or form a coating of carbon in and around the discharge valves of the compressor. If the oil is too low in flash test, the oil on reaching the highly-heated cylinder will vaporize and pass out with the air without affording any lubrication to the wearing surfaces. If the oil is too dense or is compounded with animal or vegetable oils, it will have the tendency to adhere to the discharge valves and passages and being subjected to the dry heat of compressed air, it will gradually become changed to a hard layer of carbon which will in time completely choke up the air passages and make the valves inoperative. Very little oil is therefore necessary, but it must be of the proper kind, it being the surplus oil that gathers around the valves and in the passages and being burnt causes the trouble.

The watt is the unit of electrical power and is the equivalent of one volt multiplied by one ampere. The multiplication, therefore, of any number of volts by the number of amperes flowing in a direct current circuit gives the number of watts. A watt is also equivalent to the expenditure of 44.24 foot pounds of mechanical energy, so that one horse power is equivalent to 746 watts, or one watt is equivalent to 1-746th of a horse power.

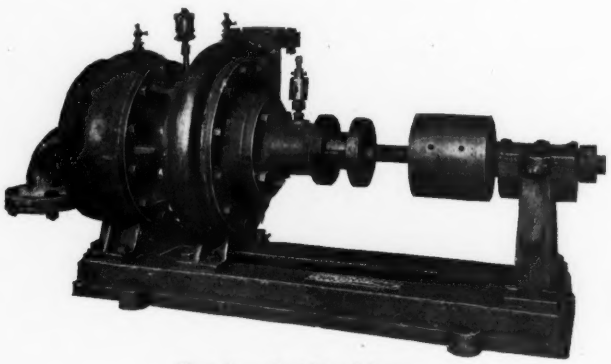
In finding the storage space required for a certain number of tons of coal, multiply the number of tons by 50 and the result will be the number of cubic feet required. For instance, if 300 tons of coal are to be stored, it will require 15,000 cubic feet of space, or a bin 50 feet long by 30 feet wide by 10 feet high.

HIGH-PRESSURE TURBINE MINING PUMPS

By Frank C. Perkins.

Centrifugal pumps are now being utilized more extensively than ever before on account of their easy adaptation for electric drives, not only for mining service where high-head pumping is required, but also for irrigation, reclamation and general pumping services. The centrifugal pump is utilized extensively in America, operated with vertical shafts as well as horizontal, the single stage pump being used where the head is low. The accompanying illustrations show horizontal shaft, two-step, four-step and five-step pressure pumps of American construction, as built at Oakland, Cal., by the United Iron Works.

The two-stage as well as four-stage and five-stage pressure pumps are now being used to advantage for mining service and it has been found practical to utilize the electrically operated centrifugal pump for both high-pressure and low-pressure service with excellent satisfaction. The 3-inch 12-inch runner, four-step pump, shown in accompanying illustration, has a capacity of 225 gallons per minute and is suitable for operating against a head of 240 feet, the speed required at this head being 1250 revolutions per minute. This pump is also capable of

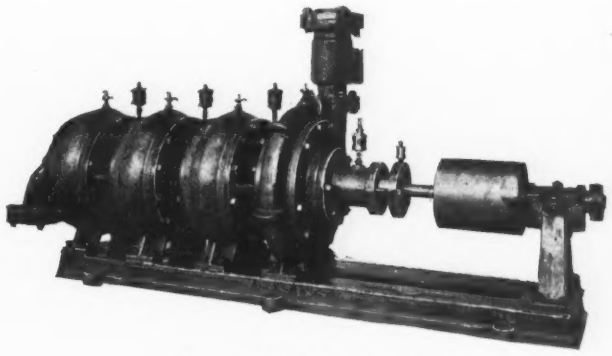


Two-Step Centrifugal Pump.

being operated against a head as high as 325 feet when the speed is increased to 1500 revolutions per minute.

The 4-inch, 18-inch runner, five-step pressure pump, shown in accompanying illustration, driven by an electric motor, is operated at a speed of 880 revolutions per minute. The electric motor to which this five-step pressure pump is directly connected has a capacity of 75 horse power, and the pump is designed to operate against a head of 350 feet, when pumping four hundred gallons per minute. It will be noted that there are pipes on the top of the pump for priming and for venting. In the centre of the pump will be noted a relief valve used as a matter of protection against water ram or operating against closed gate on discharge. These pumps have internal lubrication by means of compression grease cups, although frequently sight-feed oilers are employed, which feed by hydrostatic pressure taken from the discharge case.

The accompanying curves or duty sheets are of interest as showing the efficiency and economical range of capacity of pressure and kinetic pumps, the ordinates indicating the discharge in gallons per minute, and the absiscas indicating the head in feet. One of the curves shows the efficiency and discharge of a 5 inch centrifugal pump direct connected to a 30 horse power induction motor, while the other curve shows the comparison of discharge and efficiency of a pressure and kinetic pump which have a discharge of 1000 gallons per minute

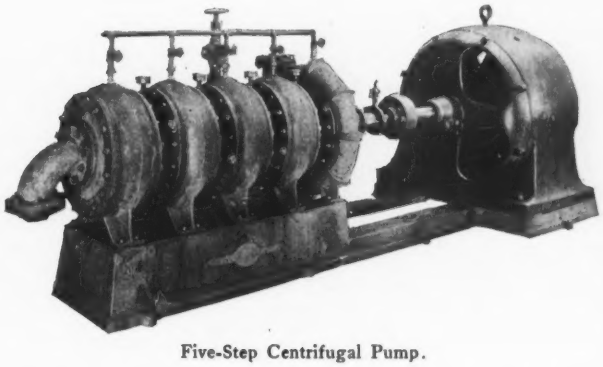


Four-Step Centrifugal Pump.

when operating under a head of 100 feet at a speed of 850 revolutions per minute.

Centrifugal pumps are now being installed of very large capacity for a city service operating by electric motor of high power, as at Buffalo, N. Y. A 1500 horse power General Electric vertical type of electric motor has been installed at the Buffalo Pumping Station, directly connected to a two-stage centrifugal pump constructed at the Snow Steam Pump Works. This pump has a capacity of 25,000,000 gallons per day and is designed to be operated on the three-phase alternating current power transmission circuit of the Niagara Falls Power Company.

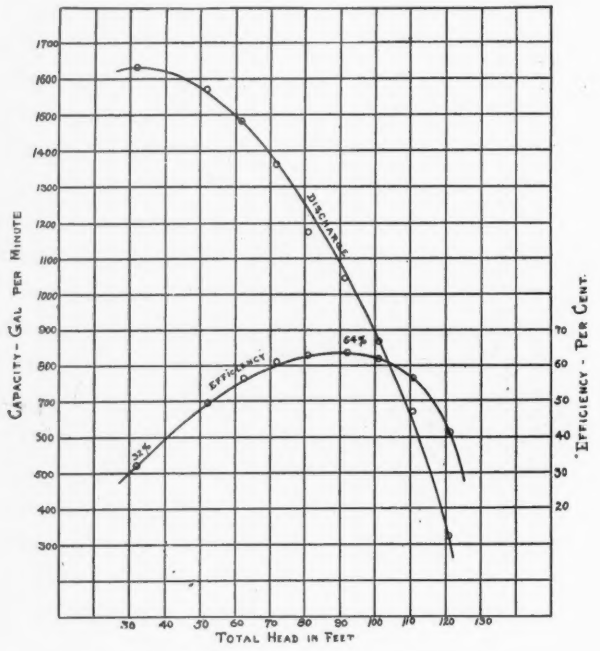
Another pump of the same capacity is proposed for im-



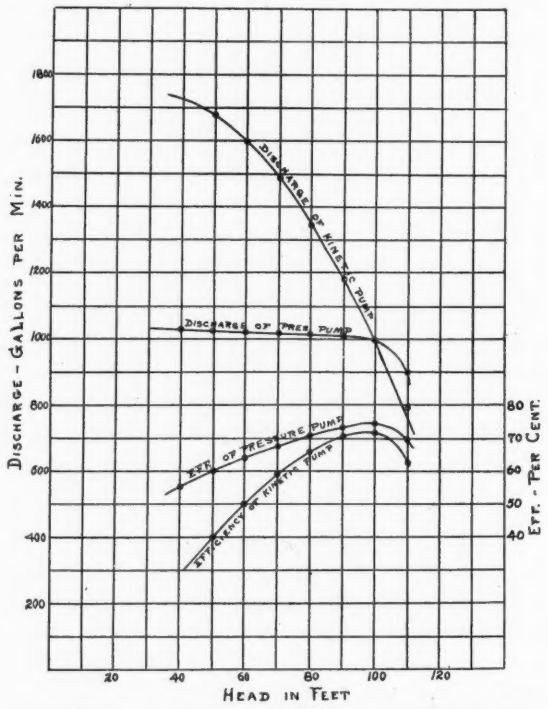
Five-Step Centrifugal Pump.

mediate construction by the Allis-Chalmers Co., of Chicago, to be operated by a Bullock alternating current motor of the 3-phase vertical type. The city of Buffalo has contracted with the electrical companies for operating the first pump at a rate of $4.50 per million gallons pumped, against a head of 200 feet. It is claimed that the cost of operating the steam pump for the same service is $5.40 per million gallons pumped and

if the electric pumps give satisfaction, a new pumping station will be constructed equipped with eight or ten electrically operated centrifugal pumps of the 2-stage type, each having a capacity of from 1300 to 1500 horse power, the total power used at this station to be from ten to fifteen thousand horse power, all of which will be transmitted from the Niagara Falls Power Plants, several of which are competing for supplying the city with the necessary electric current.



Test of 5-inch Centrifugal Pump direct connected to a 30 H. P. Motor.


Discharge - Gallons per Min.
Eff. - Per Cent.
Head in Feet
Discharge of Kinetic Pump
Discharge of Pressure Pump
Eff. of Pressure Pump
Efficiency of Kinetic Pump

Comparative Discharge and Efficiencies of Pressure and Kinetic Pumps. Capacity 1000 Gallons per minute. Head 100 feet. Speed 850 R. P M.

WILL THE PUMP DRAW WATER

By C. E. Smith

It was with considerable interest that I read the problem of the pump in your October issue and I am pleased to submit the following discussion. The solution proved much more complicated and more interesting than I anticipated, but I can now say that the pump *will* draw water. Theoretically, the pump can be far from perfect but practically it will need be reasonably close to perfection or to be capable of producing a high degree of exhaustion.

Simply stated, the problem is this: A pump is located 10 feet above the surface of water in a well and connects with the water by means of a suction pipe with several bends, as shown in Fig. 1. In the suction pipe are enclosed bodies of water, BCD and FGH, and portions of air, DEF and HIK, all being under atmospheric pressure, which for the purposes of the problem may be taken as 14.7 pounds per square inch absolute.

When the pump is started it exhausts air from AB and the water rises above B, F and K, and the air in the tubes expands. For the latter reason it is necessary to know the volume of air in each portion of the tube or, as the cross section is constant, the length measured along the centre line of the tube of each portion of air. For this purpose, the radius of each bend will be assumed to be one foot, then the length of such a portion as ED will be $(5-1)+1.57=5.57$ feet. The length of each portion of air will vary inversely as the absolute pressure.

First let it be assumed that the air in AB has been wholly removed and the first part of the water occupies the position AC, Fig, 2, and let X represent the absolute pressure at A in pounds per square inch. As the difference of elevation between A and C is 10 feet and the weight of a column of water 1 inch square, and 10 feet high is 4.34 pounds, it is evident that the pressure at C must be 4.34 pounds per square inch greater than at A, in order to hold the water in the tube AC. Then the absolute pressure at C and consequently from C to the next portion of water is $(X+4.34)$ pounds per square inch. The length of the portion of air DEF, Fig. 1, at a pressure of 14.7 pounds per square inch is $2\times 5.57=11.14$ feet. Then the length of the portion CEF', Fig. 2, is $(14.7\times 11.14)\div(X+4.34)$. The distance CEF is equal to $3\times 5.57=16.71$ feet and the difference between CEF and CEF' is $16.71-(14.7\times 11.14)\div(X+4.34)$ is the distance FF', or the distance the water has risen above F.

The remainder of the mathematical work is similar in character to that given in the last paragraph. In working out the value of X, the absolute pressure at A, Fig. 2, is found to be

7.3 pounds per square inch. The absolute pressure, C to F, is then 11.7 pounds and from H′ to K the pressure is 14.0 pounds; F′ is 2.7 feet above F, H′ is 2.7 feet below H and K′ is 1.8 feet above K.

To simplify the problem, it can be assumed that the water

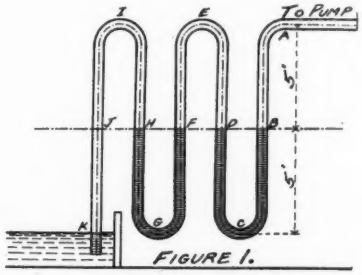


FIGURE 1.

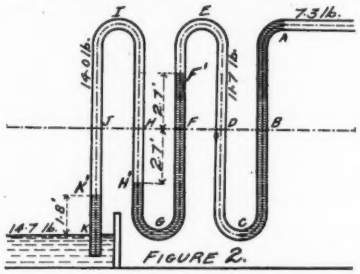


FIGURE 2.

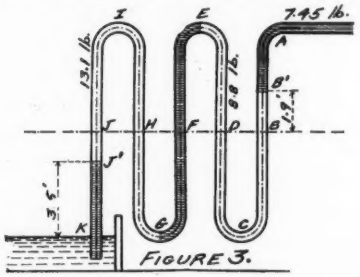


FIGURE 3.

continues up the tube AC without breaking apart or without allowing any air to bubble up through it. The practical case of slow flow in a large pipe which allows the air to bubble through the water will be considered later. The pump then in removing water from AC raises the level in EG until it reaches E, Fig. 3. Then the absolute pressure at the pump is 7.45 pounds per square inch; from B′ to E, 8.8 pounds; from G to J′, 13.1 pounds; B′ is 1.9 feet above B and J′ is 3.6 feet above K, as shown in Fig. 3.

When the water level reaches I, Fig. 4, all the water is out of the tube AC and that portion originally occupying the space from F to H now occupies the position EC, Fig. 4. As a matter of fact, at this stage the water level in EC is 0.6 feet below E, but as this is so close to E it will be neglected. Then the weight of water from C to E exactly balances the weight of water from I to K, with the result that the absolute pressure at the pump is the same as at K, or 14.7 pounds per square inch, while the absolute pressure from E to I is 10.4 pounds. This pressure at the pump remains at 14.7 pounds while the water moves from C to B and from I to G, the portion of air IE, Fig. 4, at 10.4 pounds absolute, closing up to DG, Fig. 5, at 14.7 pounds absolute. At this point the water from B to C balances that from C to D and that from G to I balances that from I to K. When the water level at G, Fig. 5, reaches E, all other water is out of the tubes and the absolute pressure at the pump is 10.4 pounds per square inch. This pressure increases to 14.7 pounds again when the water reaches C and decreases to 10.4 pounds per square inch when it reaches A. At this point all the air has been pumped out of the tubes and the pump will continue to draw water indefinitely with an absolute pressure of 10.4 pounds per square inch.

It can be proven in a similar manner that the pump will draw water even if the water column breaks or air bubbles are carried over. The extreme case is shown in Fig. 6 where no water has entered the pump as yet. Neglecting the diameter of the pipe, the difference in level between I and K will be practically 10 feet and the same between E and G and between A and C. Then as the absolute pressure at K is 14.7 pounds per square inch and the weight of a column of water one inch square and 10 feet high is 4.34 pounds, the absolute pressure in IG will be $14.7 - 4.34 = 10.36$ pounds; in tube EC, $10.36 - 4.34 = 6.02$ pounds and at A, $6.02 - 4.34 = 1.68$ pounds per square inch. If the pumping is continued any further, water will fall over the bends at I and E and enter the pump and the pressure necessary to start pumping will be somewhere between 1.7 and 10.4 pounds depending upon the speed of the pump and the size of the pipe.

The friction of the water on the sides of the pipe has been

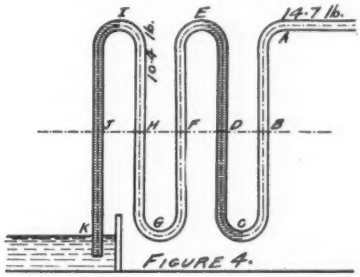


FIGURE 4.

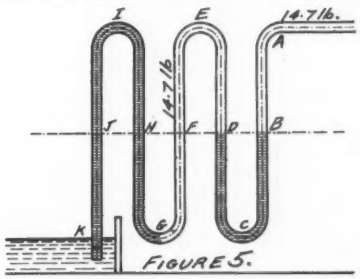


FIGURE 5.

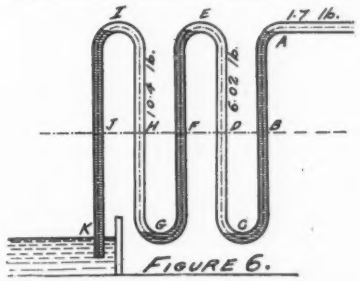


FIGURE 6.

neglected. It will probably be of no importance in the practical case considered but will increase the amount of work that is to be done in the theoretical case. On account of it, the absolute pressure to start pumping may be as low as 7 or even 6 pounds and to maintain it as low as 10 or perhaps 9 pounds. It will depend upon the diameter of the suction pipe and the velocity of flow.

THE COMMERCIAL DISTRIBUTION OF STEAM

By A. S. Atkinson.

A great many companies in our large cities have gone into the commercial distribution of steam for power and heating purposes without figuring upon all the factors which determine the rate of profits. Figuring upon the selling of exhaust steam is somewhat misleading, while basing calculations absolutely upon the distribution of live steam is a certainty. On a live steam basis, with a good market for the total output, it is easy to estimate the relative cost of producing and distribution, with the waste or loss through radiation in pipes. The companies which have good markets all the year around for their live steam are nearly all successful, and the extension of their plants is made annually to meet new demands.

However, conditions vary so much in the use of steam for either power or heating that the question of profits is more frequently complex than simple. In order to secure adequate returns even on a distribution of live steam it is quite important that perfect control of the output and installation should always be secured. Too much steam is almost as bad as too little, and the trouble will appear regularly in the monthly bills. The careless use of steam by customers must be expected. When they are paying a flat rate per month for their steam they are not particular about saving it for the producer. Even when steam is supplied merely for heating purposes, the loss is apparent among some customers who have a flat rate contract, for with the full power of the steam turned on, and with doors and windows flung open, it is possible for the customer to make profits very small for the producer. The lowering of the percentage of profits is thus quite important, and it is a factor that must be considered. The use of meters appears to regulate the difficulty, but there are many objections to this. The extra cost of the meters, keeping them in repairs and employing men to inspect and read them monthly, entails additional costs on a system that amounts to considerable in the course of a year.

The flat rate contract is the most economical if one can control the installation and distribution in such a way that a minimum of waste is produced without causing inconvenience to customers. In figuring on the distribution of steam for heating purposes in the winter season, it must be assumed that all the customers will be using the steam nearly all the time when the flat rate contract is in force, but when meters are employed fully ten per cent. can be deducted therefrom. That is, about ten per cent. of the customers will have the steam shut off for economy, and it is possible to figure upon supplying that much less than the full requirement. This is particularly true in the spring and fall of the season. Sometimes in mild weather it can be estimated at twenty per cent. It is a question whether the saving in this direction will pay for the investment and interest on meters, wages for inspectors and meter reading, and the extra bookkeeping.

The ordinary engineer engaged in the distribution of steam for heating estimates about .20 pounds of water per hour per square foot of radiation. On a flat rate basis this estimate must be taken as the standard, and it is unwise to fall much below it. The load-factor is one that varies when the meter system is used. Then these figures can be greatly reduced. The actual cost of supplying the steam or hot water for heating must depend upon the cost of fuel and its economical burning. The cost of the coal is a known factor, but its economical consumption varies greatly in different plants. The question of profits must therefore be settled by the nature of the plant and the method of operation. Unless the steam generating plant is supplied with modern improvements for economizing in the use of coal and in the distribution of the live and exhaust steam, it is questionable whether there is any profit in commercial steam selling for heating. The loss through radiation in long pipes increases the cost to such a point that it pays customers to generate their own steam.

A commercial steam plant finds it advantageous to sell steam both for heating and power purposes. The two go together, and customers desiring either one should be accommodated. In the past a good many steam companies have refused to supply steam for heating except to power customers. They figured that it would hardly pay them to run pipes to buildings where no steam was used for power. Quite the opposite is being generally recognized today. One of the surest ways to secure new power users is to accommodate them with steam for heating. When steam enters a building for supplying the radiators with heat in winter, it is natural for the customer to use steam for operating a small power plant later instead of by gas or electricity. A good many profitable steam power contracts have been made through first supplying steam for heating. With the building piped for outside steam, the installation of a local electric lighting plant is a simple matter, and the steam is used for running it. By increasing the load in this way, the company in turn supplies more exhaust steam to sell for heat.

If the live and exhaust steam supply could always be kept evenly balanced, it would be a very profitable business to sell steam for power and heating; but unfortunately the demands for the two vary so greatly in different establishments and at different hours of the day that the two must be carefully discriminated. In nearly all plants the demand for live steam is very great at certain hours of the day, and the load on the plant is high. In such cases it is more economical to have a separate boiler for use at this particular hour, or otherwise live steam will be sold on an exhaust steam basis, and the profits will be seriously eaten into. If the demand simply follows the supply of exhaust steam closely without exceeding it, the profits of heating in connection with power distribution of steam will be very satisfactory. It is only when the demands for heating run far ahead of the exhaust supply that the engineer may consider seriously whether he is not giving away steam. It is impossible to supply live steam at a profit in this way for heating unless the rates are based upon live steam cost.

If the heating is to stand upon its own merits, independent of all questions of power supply, it is very evident that the estimates of distribution must be based upon the cost of live steam, and if sufficient customers can be found to pay higher rates for the heat, the outcome of the arrangements cannot be other than satisfactory. It is very simple for the engineer to

figure out his cost and his profits. Similar conditions, however, seldom prevail. It is the combination of steam heating and steam power distribution that generally go together, and it is on this that most figures must be based.

In district steam heating, the underground pipes for distributing the exhaust steam permits of a profit where the pipes are carefully protected so that the minimum of loss of heat through radiation is experienced. The question of reducing the waste from radiation depends largely upon distances and conditions. In commercial districts the hours of service are usually shorter than those for residences, but then the number of feet of pipe for the latter is nearly always greater. That is the commercial service is more compact and dense, and the loss through wide distribution is less than in residence districts. Moreover, the same service can generally be arranged for two or more customers in the commercial district, and the cost of laying the pipes is proportionally lower. As a rule, the commercial business proves the most profitable, especially when cost of supplying heat is figured closely upon the number of hours a day that the steam will be required. The quantity of the steam required is always greater in the commercial district, and the density of the load is a matter of prime consideration. The greater the quantity of heat supplied per foot of main the more will the relative profits amount to. The loss at night time must, of course, offset the greater gains in the day time, but usually such commercial buildings require the operation of some small power plants all night, which is a feature that is encouraging. For instance, the question of individual installation of electric lighting plants in buildings is one that is rapidly coming to the front. The large office buildings find it more economical to have their own electric plants for operating elevators, fans, refrigerating apparatus and for lighting the buildings. Now where steam is introduced in the building from outside sources, the most economical method of procedure is to utilize it for driving the electric dynamo. The time is rapidly approaching when steam companies must consider this feature of their work more than ever. It is the most natural solution of present vexing problems. Commercial supplies of steam for heating office buildings would thus be utilized for light loads at night time and throughout the summer season. By securing a more uniform load and a longer season, the steam companies could provide surer returns upon their investments.

A good many companies furnish heat on a flat rate system at so much per foot of radiating surface per season, or so much per cubic foot contents per season. In making such contracts the length of the season is of prime importance. It is somewhat difficult to secure exact returns from estimates based upon our varying climate, and the engineers frequently find their figures far from satisfactory.

A steam plant properly installed, with a system of distribution economical and efficient, can furnish steam heat to offices, stores and residences thirty to forty per cent. cheaper than the individual house owner could do it with his own boilers in the basement with coal at six dollars per ton. This can be done with a good profit to the steam company. A fairly high rate for the steam can be demanded, and provided the customers find their bills lower than if they operated their own plants, satisfaction will be given. A good many will consider the dirt, ashes and bother of running their own plant a sufficient reason for taking steam from outside sources, and in addition to this there is the saving in basement space which can be used for other purposes.

Both for the sake of the customer and for the regulation of the steam from the main plant, it is essential that the equipment of each house or office should be arranged so that the steam is under the control of the engineer. A system of control in the steam heating main applicable to all boilers requires a little more initial expense, but it more than pays for itself in economical distribution and control of the steam. One of the chief losses in supplying steam is in mild weather when the amount of radiation cannot be checked, but by a simple method of control this can be avoided.

The steam admitted from the street in the pipe should rise to the highest point in the basement. A reducing valve should be placed in the pipe so that the pressure can be reduced to five ounces and maintained there indefinitely. The pipes are drained by gravity at the point where they leave the building. An indicating valve at the top of the radiator should be provided, and sufficient steam can be supplied then for heating in any kind of weather without wasting an excess. The water is conducted from the radiator by a pipe to the basement. The most dissatisfaction of customers comes from the single pipe system, and at the same time it is not possible to control the steam so economically. The control of the steam, and a regulation which enables the engineer to know how much heat is needed for any weather, must always redound to the benefit of customer and producer.

In installing a steam plant for supplying power or heat, the relative expansion of the city and its industries must always be considered with a view to keeping abreast of changing conditions in the work. Installations should anticipate larger markets, and then with a greater capacity than is needed, proceed to develop new trade. It is the greater profit obtained from supplying large volumes of steam that the management should aim for. A small steam plant is relatively more costly to maintain than a large one, and profits will increase with size and volume while rates can be reduced to meet competition. A company with pipes already laid can easily secure old customers, but the chief aim should be to branch out and obtain new ones.

In cities supplied with district steam heat, electric manufacturing companies are aiming to make suitable dynamos and machinery for individual buildings to be driven by the steam from outside sources. This adaptation of a new industry to an old promises to simplify steam engineering and greatly benefit those who need the services of electricity in a small way in different parts of the buildings. It is a field that has been developed by changing conditions, and it should receive the careful study of steam engineers and contractors anxious to find new customers for their power.

A well fitted and keyed flywheel will sometimes work loose, owing to the heating and cooling of the shaft and hub, a sudden jar, as when water is in the cylinder, will sometimes have the same effect and frequent reversals of the engine as in a rolling mill engine will have the same effect.

It has been estimated that each square foot of uncovered steam pipe costs over half a ton of coal per year to maintain.

METHODS OF SUPPORTING STEAM PIPES

By James E. Noble.

Of the various methods in use for supporting steam pipes, some are to be condemned while others are to be commended. One of the reasons why many lines of pipe are not supported properly is because many steam fitters in laying underground or overhead lines are apt to be careless, knowing as they do that some other man will have charge of their work and any trouble that may occur in the future will have to be shouldered by the engineer in charge, so it is often up to the engineer to make the fitter do the work properly or else change the supports himself.

A method used in underground work which is not recommended is that shown in Fig. 1. In some cases when the supports are at the end of a run or are near expansion joints

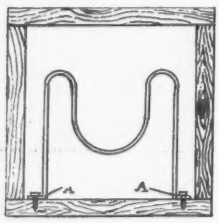


Fig. 1.

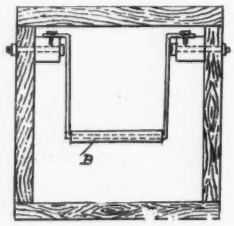


Fig. 2.

where the movement of the pipe may be several inches, the pipe has a tendency to drag the top of the stand with it as it expands, and in many cases the stand fails to return to its upright position when the pipe contracts. The effect of this in a short time is to draw the support over so far that it allows the pipe to sag. Another reason when the method in Fig. 1 is not a good one is because, as the pipe contracts and expands it is likely to draw the top of the support backwards and forwards until the support either breaks at A or works the screws out.

A method for suspending pipes underground which has been used successfully is shown in Fig. 2. *B* is a piece of pipe which rolls with the contraction and expansion of the steam pipe. Fig. 3 is another method which is giving good results in heavy work where a permanent job free from trouble is required. The guide pieces, CC, are placed about every 25 feet and D is a piece of pipe large enough to allow it to turn freely on bolt E.

For overhead work, a hanger shown in Fig. 5 is often used but the same objections apply to it that apply to Fig. 1. A

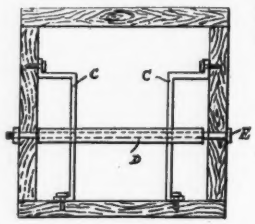


Fig. 3.

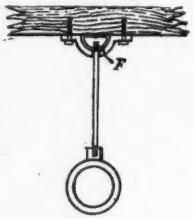


Fig. 4.

Fig. 5.

very much better hanger, known as the expansion hanger, is shown in Fig. 4, but I have seen this kind refuse to work in a damp room where steam is allowed to enter the room. The hanger collects rust at F, which makes it bind. One of the best overhead hangers from every point of view is shown in Fig. 6, and to my knowledge this form has never failed in its duty. The eyes in the support and hanger allow the pipe to expand and contract in any direction.

A support which is often used for supporting pipes on upright timbers or walls is shown in Fig. 7, but is not recommended, as it is of constant annoyance and persists in work-

Fig. 6.

Fig. 7.

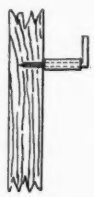


Fig. 8.

ing loose where there is the least movement of the pipe. Fig. 8 is an ideal support. It is simply a hook with a screw on one end and a piece of pipe slipped over it and it can be screwed to any vertical support, as shown.

A notable thing about most supports is the fact that the best ones are cheapest to make.

EFFECT OF THROTTLING STEAM

So long as steam remains in the presence of the body of water from which it was evaporated, it is in a saturated state and if more heat be added it will not raise the temperature of the steam, if the pressure remains constant, but the heat will go toward evaporating more water. It is only when steam is removed from the water from which it was evaporated that it can become superheated.

Saturated steam, as generally found in engineering practice, contains some moisture and is called wet saturated steam, but when all the water is taken from it, it is called dry saturated steam. Now the question often arises as to whether the moisture in the steam will be removed from the steam when it is throttled or after it has passed through a reducing valve, which is practically the same thing; or, will the steam become superheated?

A few facts will answer these questions. Steam at a certain pressure has a corresponding temperature which is fixed and as the pressure becomes lower, the temperature becomes lower. What becomes of the heat? If the reduction in pressure takes place in the cylinder of an engine, the heat is used

for performing useful work, but if the reduction in pressure takes place without any loss of heat, as the expansion in a well-covered steam pipe, then the heat liberated must be absorbed by itself. This can have then but two effects.

If there is any moisture in the steam before it is throttled, the heat which is liberated by the reduction in pressure will go into the moisture and evaporate it and if there is any surplus heat left it will go to increase the temperature of the steam, thus giving it a higher temperature than its corresponding pressure. This is called superheating. Not quite all the heat liberated goes to evaporate the moisture and cause superheat but a little is used up in latent heat, because the latent heat of steam at low pressures is greater than at high pressures.

It is upon this principle that throttling calorimeters operate. Steam of high pressure is made to expand through a small opening which lowers the pressures. Thermometers and gauges are placed on each side of the opening and it can be calculated how much moisture was in the original steam. The thermometer is higher than the temperature corresponding to the pressure in the proportion to the quality of the original steam.

In passing through a throttling or reducing valve, the steam is made dryer by this reduction in pressure and as much as 3 per cent. moisture can be evaporated from the steam, but if there was very little moisture in the steam at the start, then the reduced pressure steam would be slightly superheated over the temperature corresponding to the lower pressure.

If a pound of steam at 120 pounds gauge pressure is throttled, the following changes take place: At 120 pounds gauge pressure, the temperature of the steam is 350 degrees, the latent heat is 867 heat units and the total heat above 32 degrees is 1187 heat units. Suppose the pressure is reduced to 60 pounds gauge, then the temperature has been reduced to 307 degrees, the latent heat increased to 899 heat units and the total heat has become 1176 heat units. In reducing the pressure, the temperature dropped from 350 to 307 and there was liberated 43 heat units, but since the latent heat increased from 867 to 899, 32 of those heat units were absorbed by it, leaving 11 heat units with which to evaporate moisture in the steam or superheat it.

Generally speaking, it takes about one-half a heat unit to raise the temperature of steam one degree, so that these 11 heat units would raise the temperature of the steam about 22 degrees above the temperature, corresponding to the pressure if there was no moisture present. If there was moisture in the steam it would have a temperature of 307 degrees, the same as that of the steam. Now it requires 899 heat units to evaporate one pound of water from and at that temperature and since there are only 11 heat units available, this amount of heat, being liberated for each pound of steam expanded, would be capable of drying out 11-899ths, or about 1¼ per cent.

How to Interpolate the Table of Factors of Evaporation.

By Chas. J. Mason.

It sometimes happens when it is desired to use the table of factors of evaporation, that the given figure for any case falls between two certain figures in the table, and therefore the correct result cannot at once be found without resorting to what is called "interpolation." In connection with the article and table which appeared in the September issue of The Practical Engineer, and which is reproduced for convenience, the following method of interpolation of table of factors of evaporation may be of interest to some of the readers.

Suppose, for example, that the average steam pressure in the boiler is 64 lbs. per square inch gauge, and that the average temperature of the feed water is 132° F.; what is the factor of evaporation? Now, by referring to the table, we find no columns with heading or side heading corresponding to these figures, and unless we have some definite method of obtaining exact figures, we should have to guess and strike an average between two sets of figures in the table, nearest to those given in the example. While for ordinary purposes this would be close enough, yet because of the ease with which the real figures may be found, it is worth while to learn what to do.

The factor for 60 lbs. gauge and 130° feed water is 1.115 +; the factor for 70 lbs. gauge and 130° feed water is 1.118 +; the factor for 64 lbs. gauge and 130° feed water is therefore,

$$1.115 + \frac{1.118 - 1.115}{10} \times 4 = 1.1162.$$

In the same manner, the factor of evaporation for 64 lbs. gauge pressure and 140° feed water is found to be

$$1.105 + \quad + \frac{1.107 - 1.105}{10} \times 4 = 1.1058.$$

We now have the factor for 64 lbs. gauge and 130° feed water, and 64 lbs. gauge and 140° feed water, and it now only remains to interpolate between these values to get the factor for 64 lbs. gauge and 132° feed water. This is done as follows:

$$1.1162 - \frac{1.1162 - 1.1058}{10} \times 2 = 1.1141 +,$$

which is the factor of evaporation corresponding to 64 lbs. gauge pressure and 132° F. feed water, as given in the example.

The foregoing method may be applied to any figures within the range of the table.

Polyphase generators for a given output are smaller and cheaper than single phase, and three-phase generators are often installed for single-phase working. Three-phase generators will ordinarily deliver two-thirds of their rated capacity in single-phase current between any two terminals with the same heating as when delivering full three-phase load.

High frequency alternators are now becoming obsolete and the standard frequencies are now 60 cycles for lighting and power and 25 cycles per second for power only. These correspond to 7200 and 3000 alternations per minute.

A short rule which is often used for finding the safe speed of the rim of a flywheel when the diameter is given is as follows: Divide the number 1680 by the diameter of the wheel in feet; the result will give the maximum safe number of revolutions per minute. For instance, if the flywheel is 12 feet in diameter, then $1680 \div 12 = 140$ revolutions per minute.

In single-phase alternators, all the coils on the armature are connected in series. For two- and three-phase machines, the coils are connected so that they will give the proper phase relation, wires being carried from these points to the machine terminals.

The
Practical Engineer

DEVOTED TO THE ECONOMICAL GENERATION AND UTILIZATION OF POWER

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Review of the Steam Turbine Problem.

During the past year, the prominence which has been given to the steam turbine has surpassed that of any other piece of apparatus in the engineering field. This is not because it is new in principle but because of its recent wide application in driving electrical generators in large power houses.

More than sixty years ago, patents were taken out on steam turbines, in which all the essential points for constructing an excellent turbine were clearly set forth and it is therefore curious, when the correct principles of construction were so clearly understood, that practically nothing should have been accomplished until Parsons, working along entirely different lines, succeeded in proving that a steam turbine could furnish power as economically as a reciprocating engine.

The principal pioneers in the turbine field were Pilbrow, who in his patent of 1843 described a steam motor very closely allied to the De Laval and Parsons type, Robert Wilson, who in 1848 described the system of compounding for velocity which has been introduced of late years by Ferranti, Curtis, Reidler and Stumpf; and Thomas Baldwin, who in 1873 described a steam turbine closely allied to the compartment type which has recently been developed by Prof. Rateau.

There were several reasons why the steam turbine did not meet with success in the early days, among which may be mentioned the lack of accurate workmanship and the small sizes in which they were made and it was not until 1892 when the steamer Turbinia made her remarkable trials that the steam turbine was considered seriously as a prime mover. At the present time there are a number of steamships building which are being fitted with steam turbines, although no less an important personage than Admiral Melville, retired chief engineer of the U. S. Navy, does not recommend the turbine for that class of service.

In the stationary field, the application of the steam turbine in this country may be said to date from about the year 1899, the first prominent installation being installed and ready for service in August of that year at the Westinghouse Air Brake Co.'s works, at Wilmerding, Pa., where Parsons' turbines of 400 kilowatt capacity were installed. This was followed in 1901 by the installation of a 1500-kilowatt turbine in Hartford Electric Light Co.'s plant, and in 1902, by the 400-kilowatt installation at the plant of the Yale and Towne Mfg. Co., at Stamford, Conn. Since that time there has been a rapid advance in the application of the turbine and when all the turbines which have recently been ordered are installed, approximately 1,000,000 horse power will be generated by this type of prime mover.

Not all the turbine plants have been successful but the advocates of the steam turbines claim that almost all the failures were due either to improper workmanship or carelessness in operation. Whether these are the reasons or not, the fact still remains that reports are coming in which indicate that the steam turbine builders have still a lot to learn before their machines can be considered as reliable as the reciprocating engine. This fact has made such an impression that one of the largest power plants in the South is being equipped exclusively with reciprocating engines because there does not seem to be any reliable data as to the actual service performance of large units over any considerable length of time. So important is this problem that quite a number of plants are installing turbine units with the distinct purpose of finding out not only their economy, but their reliability in service, wear and tear and life of the parts.

The year 1905 thus closes with a large number of steam turbines in use and a greater number in building. If the year 1906 shows that these turbines answer the engineering requirements which are demanded of them, then its future is bright indeed.

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Variation of Electric Loads.

In connection with all central station electric plants, the variation of the load with the character of the service is most interesting. A pure lighting load diagram has almost invariably but one peak in twenty-four hours. The time of day at which this peak or maximum load occurs depends upon how far north or south the city is located, whether the station supplies a business or residence section, the season of the year or the kind of weather. In a residence district, the maximum load will occur about the time of the evening meal, while in the business district it will occur late in the afternoon, shortly before closing hour.

In city electric railway plants, the load diagram has two peaks, one in the morning and one in the afternoon. The morning peak is due to the load caused by the people going to work, while the evening load is caused by the people flocking homewards. In smaller factory towns these peaks are most pronounced, since almost everybody goes to work at one time and leaves work at one time.

In larger cities, which contain stores, office buildings and factories, the maximum load on the power plant is greater in

the evening than in the morning, because the time of starting work varies from 7 A. M. to 10 A. M., after which the ladies come out to do their shopping but nearly everybody wants to go home at nearly the same hour in the evening. This causes a very much sharper peak in the evening than in the morning.

When motors are supplied from a lighting system, they alter the character of the load diagram and tend to produce a decided depression of the load curve during noon hour when most of the motors are shut down, or if the motors continue to run, the load is taken off, thus reducing the power required. When theatres or saloons are supplied from a lighting circuit, they also alter the load curve, since they demand the greatest amount of power between 8 P. M. and 11 P. M.

However, whatever the character of the load for any given circuit, it will usually repeat itself night after night or day after day in the most automatic fashion, showing how very regular are the actions of humanity. Take, for instance, the telephone load which also has its characteristics. It is a maximum about twice a day, in the morning and in the afternoon, with a decided let-up about noon, when either the person who usually calls is out to lunch or else he is deterred from calling, thinking the other fellow is out to lunch.

To the person who is familiar with load diagrams, the reading of the curve will indicate at once what kind of load the station is carrying, what kind of people live along the circuits and what their regular habits are. Its particular value to the engineer is to show what maximum amount of power is required and what ratio it bears to the average load throughout the twenty-four hours.

It is the peak of the load diagram that is the least desired by all station managers and everything is usually done in large stations to smooth out the peak, either by putting in storage batteries or else by seeking and attracting users of power to even up the load.

—o—

Visiting Steam Plants. Every engineer who desires to succeed and improve himself should, whenever the opportunity affords, visit all the mechanical plants in his vicinity. It is a very bright man indeed who cannot learn something by seeing the arrangement of mechanical apparatus in some plant other than the one with which he is connected. It may be only the arrangement of piping, or the kind of steam trap used or the tools used in firing or some method of making repairs, but whatever it may be, it will often unconsciously increase his knowledge, which while it may not be useful for some years, may eventually be used by him with marked success.

There are lots of things we know, and we don't know we know them until we are put to the test and often we cannot tell how we learned them; but upon analysis it may be that we remembered about 10 years ago how Bill Jones did that very same thing or maybe perhaps we read about it. However that may be, many things that are seen in the course of a visit to a power plant may become useful.

In this connection it might be said that more visiting among plants would be done if there was not so much jealousy existing among engineers. At a recent meeting of an engineering society, a gentleman who has examined thousands of engineers applying for a license, said that he thought that if there was one thing which hurt an engineer in particular and especially the engineering profession in general, it was the jealousy which was manifested between them. Instead of a new engineer exposing the faults of his predecessor to his employer, he should shield him as much as possible and in that way any mistakes which were made would not become generally known.

The different engineering societies and clubs are perhaps doing more to overcome this than any one thing, for it is in such social intercourse that it is found that a certain fellow is very much nicer than you thought he was and the next time he comes around to your plant he will be a welcome visitor.

If possible, however, engineers should become acquainted with their engineering neighbors and in time of difficulty or trouble, they should stick together and help each other whenever possible. If this seems to approach too near the millennium, then at least opportunity should be taken to visit whatever plants are accessible.

Large companies take advantage of the value of visiting plants by sending their head men around the country to visit other plants so that they may bring back knowledge that can be acquired in hardly any other way.

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Single-Phase Railway Systems. The single-phase railway system, which is now attracting universal attention, interests a great many stationary engineers because, while the design of the power house may not be materially affected, yet the system of distribution is somewhat changed and it will probably affect the kind of prime mover to be selected in the future.

The first electric railway in this country to place a single-phase system in operation was the Indianapolis and Cincinnati Traction Company, who on January 21st last opened service between Rushville and Morristown, 16 miles apart. The latest road which has announced its intention of installing the single-phase system is the New York, New Haven and Hartford Railroad, so that the single-phase alternating-current system can now be said to have passed the experimental stage.

The use of high voltage for distribution is the attractive feature of this system, as is also the fact that single-phase motors can be used on direct-current circuits. The method of distribution consists of a power house generating a voltage of 30,000 or higher and at every 10 or 12 miles the voltage is cut down by means of oil-insulated step-down transformers to a comparatively low pressure of about 3000 volts. The high-tension current is carried from the central power station to the transformer stations on No. 4 bare copper wires, there being two wires to each transformer station. This makes a complete circuit and permits the placing of circuit breakers and switches at the central power station, so that everything along the line can be governed from the central point.

When the alternating current lines reach a city or town, they can either be replaced by low-voltage alternating-current, or by 550 volt direct current, the single-phase motor working equally well on either circuit. Two trolleys are used, one with a trolley wheel for low-pressure direct-current or low-pressure alternating-current and the other of the bow type for high-speed high-voltage service.

From the above, it can be seen how very flexible such a system is and since the length of trolley lines is constantly increasing and since steam roads are now adopting it, the single-phase system should become an important factor in that class of service but it is doubtful if it will ever replace the direct-current system in large cities.

LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

What Makes an Engineer?

EDITOR THE PRACTICAL ENGINEER:

The following is what I consider a man should do and what he should be to become a successful engineer:

An engineer of today, if he wishes to succeed, has many hours of trial and study before him. He should be strictly temperate, because no one that handles liquor is competent to handle steam. He should be strictly honest in every way. He should have a practical knowledge of the construction of engines and should know how to care for them, set the valves, adjust boxes, etc. He should understand the construction of the boiler and its safe working pressure, for I think more accidents are caused by ignorance of danger than any other one thing. He should also understand the construction of dynamos and motors; that is, he does not need to be a designer or a thorough electrician but he should know about them in a practical way.

There are several ways of getting this knowledge, providing he has what nature should give. He may travel about, picking up knowledge here and there as he finds it, or he may learn it from reading, but I think the most practical way for a young man who wishes to work up to a higher standard is to start in as an oiler or assistant-fireman of any good plant and watch what is going on around him and read mechanical papers during leisure hours. In this way he will fast become a good practical man, capable of going before an examining board of steam engineers and passing their examinations. Until he can do this, I do not consider him competent to take charge of a steam boiler or engine, no matter how small it may be.

Rose Hill, N. Y. M. E. WEBBER.

Methods of Reversing Motors.

EDITOR THE PRACTICAL ENGINEER:

Now that the electric motor has gained a prominent place in the modern engine room, as an auxiliary, being used extensively for operating large valves, cranes, in connection with some types of automatic steam-engine governors, etc., and when doing such work as these motors must be equipped so as to be readily rotated in either direction, engineers should familiarize themselves with the methods used for reversing same, and thus save expense and time in the case of a new installation, or accident to the old wiring.

In order to reverse the direction of rotation of a motor, it is necessary to reverse either the armature, or field terminals, but not both at the same time. If both the armature and field terminals are reversed at the same time the direction of rotation will not be altered.

If a motor is in operation and it is desired to reverse it, allow the speed of the armature to fall a large per cent. below normal, or to come to a stop before throwing the switch to the reverse position. If the switch is thrown to the reverse position while the motor is up to speed, its counter E. M. F. will be added to the applied E. M. F. instead of opposing the latter, as under ordinary conditions, and will send a large current through the armature which would be equivalent to a short-circuit.

Fig. 1 shows the connections for reversing a series-wound motor, using a special type of reversing switch. In the diagram the line terminals are marked + and —, f and f' are single-pole fuse mains, S is a double-pole, single-throw knife switch R. S. is the reversing switch, R is a starting resistance, A the motor armature and F the field coil. In the diagram a starting resistance is shown in series with the armature, though it may be well to state that a starting resistance is not necessary in connection with a series-wound motor, providing the capacity of the motor is below five horse power; the field coil being in series with the armature offers sufficient starting resistance to the flow of the current.

In the case of a shunt-wound motor, however, a starting resistance must always be inserted in series with the armature, as the field coil is shunted across the line, thus leaving the armature to be connected directly to line. If the "dead" armature of a shunt-wound motor were connected directly to line, a large current would flow through the armature, owing to the low resistance of the latter, and in the failure of the fuse or circuit-breaker to open the circuit promptly a "burn out" would result.

If, for any reason, it is inconvenient to use the type of reversing switch shown in Fig. 1, the same result can be accomplished by using a triple-pole, double-throw knife switch, of which Fig. 2 is a diagram of connections.

Fig. 3 shows the connections for reversing a shunt-wound motor, using the reversing switch shown in Fig. 1, and Fig. 4

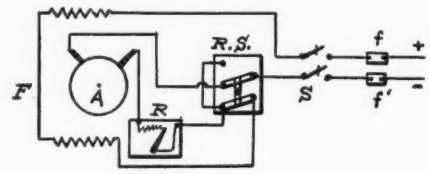

Fig. 1.

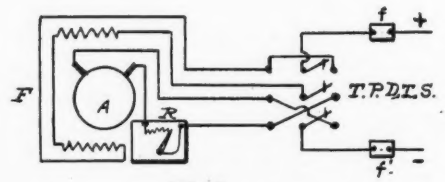

Fig. 2.

shows the method of reversing a shunt-wound motor, using a double-pole, double-throw knife switch.

To change the direction of rotation of alternating current motors, proceed as follows: If the motor is a single-phase synchronous motor, simply drive it up to synchronism in the opposite direction and when in synchronism connect it to the

alternator. If the machine is a single-phase induction motor, having a phase splitting arrangement, reverse the terminals of one set of coils of the motor, leaving the other two connections unchanged. When the motor comes up to speed, the ohmic resistance and the inductive resistance are short-circuited so that the machine runs as a single-phase motor. For a

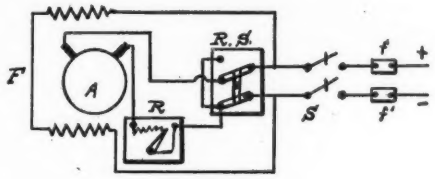

Fig. 3.

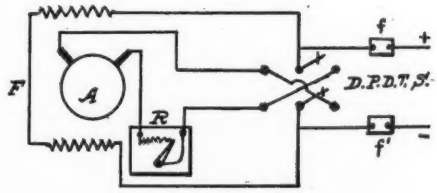

Fig. 4

two-phase motor, reverse the two wires of one phase, leaving the other two wires of the other phase the same. If the machine is a three-phase motor, reverse the connections of two of the three line wires.

New Orleans, La. A. C. KELLY.

Remedy for Some Engine Troubles.

EDITOR THE PRACTICAL ENGINEER:

The following are some of the engine troubles I have had and the remedies I used to cure them: The crosshead pin on an engine of the Corliss type got so hot that the engine had to be shut down. Upon examining the box and pin nothing could be found that was wrong so I cooled the box and pin and covered them with cylinder oil. When the engine was started, within one hour the pin was hot again and I had to shut down. I could not understand what was the trouble as I was using a good grade of oil and was giving the engine plenty of it. I removed the box and pin again from the crosshead and by examining them close this time, I found that the box was rubbing hard against one side of the crosshead. It was found that the cause was the crank shaft being out of line and when the shaft was put in line the heating of the pin stopped.

Another engine of the Corliss type had a bad pound in the main bearing but tightening up the adjusting screws would not stop it. Upon examining the bearing and shaft closely, I found that the pound was between the shaft collar and main bearing. As there was plenty of play between them, I could not see why the shaft should move endways, but at a point in each stroke the collar would strike the bearing and cause the pound. There was also a clicking noise in the crosshead at times and the pound could only be heard when the load was heavy. I let the engine run this way until the next Sunday when I took the main bearing apart but found nothing wrong. I was about to give it up and send to the works for a man, when I noticed that the outboard bearing was loose on the foundation but would only move when the load was heavy. After the bearing was tightened the pound in the bearing and clicking noise in the crosshead were heard no more.

The flywheel of another engine did not run true at a certain part of the stroke and upon examination it was found that the cap on the outboard bearing was not tight enough on the shaft and the cap on the main bearing was also too loose, which caused the shaft to be raised in the outboard bearing at a certain portion of the stroke which made the wheel run out of true. I removed some of the liners under the cap of the outboard bearing and the trouble was remedied.

Another engine of the Corliss type would pound in the cylinder at times but nothing was found wrong in the cylinder. The trouble was found to be caused by the piston rod being out of line which caused it to rub hard against the bottom of the stuffing box. As the piston head or bull ring was slightly smaller than the bore of the cylinder and as the piston rod was too low, it would raise and drop the piston head at one portion of the stroke. The piston rod was put in line by raising the crosshead and the pound disappeared.

The crosshead pin and box of an engine started to get hot but more oil would not help the trouble as the pin and box kept on getting hotter and the engine had to be shut down. Upon taking the box out, it was found that some part of the pin had lots of oil and the other part was dry. When looking for the cause of this it was found that the crank shaft was not level and this would bind the crosshead box at one point of the stroke, as the crosshead could not move sidewise. This had before given me some trouble as a pound and when I keyed the box up enough to take out the pound, it would get hot. When the shaft was levelled, I loosened the key again and the trouble was all over.

Milwaukee, Wis. H. J.

No "Ring the Bell" Method for this Engineer.

EDITOR THE PRACTICAL ENGINEER:

I read with much interest "The Power Station," by Fred N. Bushnell, in the November issue of THE PRACTICAL ENGINEER. The part which I wish to write about more particularly is regarding oilers and firemen. It don't seem to me that it should be necessary to call an oiler's attention to his duty by means of a bell, whistle, or any other alarm. I believe right here is where many men, who if properly handled would make good employees, are spoiled by treating them as you would an animal which had been trained to do certain things. Give a man certain fixed things to do, ring a bell every time he is expected to do them and you have a trained animal, nothing more or less.

I feel that I have learned by experience to point out to a man each of the several duties he is expected to perform, put confidence in him, and if he is good for anything, the duties will be performed in a satisfactory manner and it will not be necessary to ring a bell for him, either. If it becomes necessary to call a man's attention to his regular duties each time he is expected to do them, the sooner another takes his place, the better it will be for all concerned. I believe that many a good man has been spoiled by not placing confidence enough in him.

I have no doubt but that Mr. Bushnell is thoroughly capable of performing all his duties in a satisfactory manner. I wonder how he would like it if some one of the men in authority over him should ring a bell for the purpose of calling his attention to the fact that it was time some one of his duties were looked after? I say that this "big I and little *u*" business is what makes poor employees out of lots of men who would otherwise be good ones. I have been fireman and have worked up to chief engineer and I have a lot of feeling and respect for the man who shovels the coal or carries the oil-can.

Now about firemen. I don't think good firemen are hard to get, but many plants have a hard time keeping a good one and ofttimes a good one is spoiled before he gets away. A little description of the duties of the firemen in a plant where the writer was employed at one time will illustrate very forcibly why good firemen are hard to get and hard to keep.

This plant of which I speak is an electric light and power station in which are employed three engineers, two firemen and one coal-passer. The firemen are required to work ten hours for six days and thirteen hours the seventh day. During three hours of the ten they are required to fire two boilers and the remaining seven hours, four boilers. For this labor they receive the large sum of twelve dollars per week. Throughout the shift of ten hours, besides firing, they are required to wipe each high side of two cross-compound Corliss engines of 500 H. P. each, wipe two condensers, scrape boiler tubes when needed, assist in cleaning boilers every Sunday, keep all the piping in the engine and boiler rooms clean and whenever there is any painting or whitewashing of walls, boiler fronts, pipes, etc., they have to do it. As a rule, they have to assist with any repair work which has to be done in the fire-room. It is not an uncommon occurrence for the fireman to work twelve hours. No overtime is ever allowed in this plant, either.

When the writer started firing, he did so with the expectation of some day being an engineer and I believe this is true of most firemen. Now, if there is a ghost of a show for a man to learn much about engineering in a plant like the one just mentioned I would like to know it. Twice within the past two years there has been opportunity to advance firemen to engineers but outside men have been called in. When I asked why this was so, I was told the firemen had not been there long enough to gain sufficient experience to enable them to handle the plant. Knowing what I do about this plant, it seems to me a man could hardly learn to operate the plant if he fired there a lifetime. Why can't good firemen be found for such plants? Why don't they stay if a good one happens to be employed? I think the answer has already been given.

In this same plant, a short time ago, a new coal-passer was employed with the understanding he was to have a fireman's position at the first vacancy. In about two months one of the firemen left. The coal-passer did not get the promised position; an outside man was brought in, as usual. It is unnecessary to say the coal-passer left also. I know that in this plant they have had three good firemen in the past two years. They are not there now but have gone where a good fireman is appreciated. This is also one of the plants where the so-called "ring the bell" method was used. One of the engineers would not trust his fireman to shift the weights on the damper regulator when more or less steam pressure was required. Lights were even turned on and off in the fire-room by the engineer.

Pay good wages, treat your men as you would like to have them treat you and nearly always they will develop into good firemen and eventually into good engineers.

A. K. Bell.

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Engineers Should Examine a Plant Thoroughly Before Taking Charge.

Editor The Practical Engineer:

I was recently sent to see about fixing a 60 horse power tubular boiler that had been running for six seasons and which was in charge of a new engineer. The boiler had only been run a few months each year and when taking charge the new engineer was informed by the management that it was all right. He started up the plant and had only been running a week when the boiler developed a blister, a picture of which

Blister Caused by Dirt and Scale in Boiler.

is shown in the accompanying illustration. The blister occurred in the plate just over the arch and when removed from the boiler it showed a bulge of 5 inches. When examined, the blister was found to contain plenty of dirt and scale.

The point I wish to make is that it is decidedly a mistake for any engineer to rely upon what any one says. Since no matter what happens he gets the blame nine times out of ten, he should be very particular especially when taking charge of a new plant to see for himself that everything is all right before starting.

E. H.

QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

Alternating Current Phases.

EDITOR THE PRACTICAL ENGINEER:

Please explain the word "phase" as applied to a dynamo; also what the difference is between one-phase, two-phase and three-phase alternating current dynamo?

Drew, Maine. E. J. L.

In an alternating current circuit, the impressed electromotive force passes through a series of values from maximum to minimum and back to maximum each cycle. If the resultant current is maximum and minimum at the same instant that the electromotive force is maximum and minimum, then the current may be said to be in phase with the voltage. An alternator that produces a single electromotive force wave is called a single-phase machine; those that produce more than one pressure wave are called polyphase or multiphase machines. A two-phase machine is one that generates two pressure waves and the circuits thus arranged have a phase difference of 90 degrees. A three-phase machine is one which has three independent circuits and the waves of the different circuits follow each other with a phase difference of 120 degrees.—[Ed.]

Amount of Water Escaping Through Crack in Boiler.

EDITOR THE PRACTICAL ENGINEER:

In your November issue I noticed a question on page 28 about the "amount of water escaping through a crack in a boiler." In reading your solution, I noticed that where your calculated the area of the opening in square feet you used 12 as a divisor, instead of 144, as divisor in reducing .005 square inches to square feet.

Solon, Ohio. FRED. DEADY.

EDITOR THE PRACTICAL ENGINEER:

While looking over the November issue, I see quite an interesting problem submitted by H. G., in which he wants to know the amount of water escaping through a crack 1-1000 of an inch wide by 5 inches long. Can it be possible that such an opening will discharge 196 cubic feet of water an hour? The capacity of a tank 5 feet by 10 feet is 196 gallons and it does not look as if a crack of that size under a pressure of 120 pounds would drain the tank in one hour. No doubt this is of importance to H. G. and I submit my solution to the problem.

The velocity of water issuing from an orifice is the same as that which would be required by a body falling from a height equivalent to the head of water above the orifice. Thus $V = \sqrt{2gh}$, in which h = head of water, g = acceleration of gravity which is 32.2 and V = velocity in feet per second. To find the height of a column of water in feet when the pressure is known, multiply the pressure by 2.304, or, $120 \times 2.304 = 276.48$ feet. Then we have $V = \sqrt{2 \times 32.2 \times 276.48} = 133.4$ feet per second. The area of the orifice is $.001 \times 5 = .005$ square inches. Multiplying the area of the orifice in square feet by the velocity in feet per second, we get the quantity of water issuing from the orifice in cubic feet per second, or, $133.4 \times (.005 \div 144) = .0046$ cubic feet per second or 16.56 cubic feet per hour, which multiplied by 7.5 gives 124.2 gallons of water issuing from the crack in one hour.

The coefficient of discharge of water as in a jet is the proportion of the full amount discharged and has been found to vary from 0.6 to 0.8. Taking the coefficient to 0.6, we have $124.2 \times 0.6 = 74.50$ gallons per hour flowing through the crack.

Sault Ste. Marie, Mich. F. N. B.

Amount of Condensing Water Required. Amount of Coal Lost by Leaky Blow-off Valve.

EDITOR THE PRACTICAL ENGINEER:

Enclosed find my subscription for the coming year. This is my third year with you and every number seems to be better than the previous one. I would also like to ask you for some information:

(1). Are there any tables published giving the amount of water necessary to condense the steam from a compound condensing engine? For instance: If it takes 28 pounds of water at 70 degrees to condense one pound of steam, how much water at 60 degrees will it take to condense the same amount of steam?

(2). If a boiler is losing water through the blow-off valve at the rate of 18 pounds per minute, and the feed water is 200 degrees and the average gauge pressure is 85 pounds, how much coal is lost by the operation?

Freeport, Ill. W. P. F.

(1). There are tables published on the amount of water necessary to condense the steam from a compound condensing engine, but they are more or less complicated, since the weight or quantity of injection water required for a given weight of steam depends upon several conditions: 1. The pressure at which the steam is exhausted. 2. The absolute pressure existing in the condenser. 3. The temperature at which the injection water enters the condenser.

A formula which will give the amount of condensing water under any condition is as follows:

$$Q = \frac{1183 - A^\circ}{T - t}$$

in which Q = the quantity of condensing water required per pound of steam condensed, A° = temperature of air-pump discharge, T is the final temperature of the condensing water and t is initial temperature of the condensing water. The number 1183 is used because the total heat above zero degrees in one pound of steam at a terminal pressure of 5 pounds above the atmosphere is 1183 heat units.

The rule, then, is as follows: *Subtract the temperature of*

the air pump discharge from 1183 and divide the remainder by the rise in temperature of the condensing water. In the case of a jet condenser, the value of A° and T is identical, since the final temperature of the condensing water is the temperature of the air-pump discharge.

If, in the given problem, we assume that it is a jet condenser, in the first problem everything is known but the temperature of water from the air-pump. This can be worked out as follows:

$$28 = \frac{1183 - X}{X - 70}$$

$$28X - 1960 = 1183 - X$$

$$29X = 3143$$

$$X = 108 \text{ degrees,}$$

which would correspond to a vacuum of about 27.4 inches.

Assuming, then, in the given problem that the initial temperature of the feed water is 60 degrees and the same vacuum maintained, the quantity of condensing water becomes

$$Q = \frac{1183 - 108}{108 - 60} = 22.4 \text{ pounds.}$$

so that it will take 22.4 pounds of condensing water to condense the same amount of steam when the condensing water is 60 degrees.

(2). As the boiler loses 18 pounds of water per minute, $18 \times 60 = 1080$ pounds is the amount lost per hour. Steam at 85 pounds gauge pressure has a total heat above 32 degrees of 1182.9 heat units and as the feed water is 200 degrees, or 168 degrees above 32, the total heat lost by each pound of boiler water is $1182\text{-}9 - 168 = 1014.9$ heat units. Multiplying 1014.9 by $1080 = 1{,}096{,}092$ heat units lost per hour. Since one horse power is equivalent to 33,305 heat units per hour, the number of horse power lost by the boiler is $1{,}096{,}092 \div 33{,}305 = 32.9$ horse power. If it takes 3½ pounds of coal to develop one horse power, then the number of pounds of coal lost, due to the leak, is $32.9 \times 3.5 = 115$ pounds.

A much shorter method would be to assume that the boiler evaporates, say, 10 pounds of water per pound of coal, in which case the number of pounds of coal lost can be obtained by dividing 1080 by 10, which will give 108 pounds of coal as the amount lost.—[Ed.]

Flow of Air in a Vacuum. Pump Suction.

EDITOR THE PRACTICAL ENGINEER:

Kindly answer the following questions:

1. How fast will air enter a vacuum?

2. Is there friction on the suction of a pump or, in other words, is there any limit to the distance a pump will take through a suction pipe at a nominal lift, say, one foot?

3. Is air more or less flexible than steam?

Terre Haute, Ind. L. D. C.

1. The velocity with which a gas under pressure will escape into a vacuum is inversely proportional to the square root of its density; that is, oxygen, which is sixteen times heavier than hydrogen, would, under exactly the same pressure, escape through an opening only one-fourth as fast as hydrogen. For small differences in pressure the theoretical velocity in feet per second can be obtained from the formula: $v = 8.02\sqrt{h}$, in which h = height of fluid required to produce the pressure of the fluid at the level of the level of the orifice. If, for instance, there is vacuum on one side of the orifice and the pressure of the atmosphere on the other, the head in feet can be obtained from the formula: $h = p \div w$, where p = pressure in pounds per square foot, or 2116 pounds and w = weight of a cubic foot at 62 degrees temperature and atmospheric pressure, or .076 pounds, then $h = 2116 \div .076 = 27{,}842$ feet. The velocity becomes, substituting the value for h, $v = 8.02\sqrt{27{,}842} = 8.02 \times 167 = 1339$ feet per second.

2. There is friction on the suction pipe of a pump and there is a limit to the practical distance through which a pump can draw water, owing chiefly to air leaks which are likely to occur even in the best laid pipe, and also to the absorption of the suction head in the friction of the water in the pipe. For these reasons, the pump is always placed as near as possible to the source of supply and forced to the place where it is needed.

3. Air and steam follow practically the same laws of thermodynamics and have about the same flexibility.—[Ed.]

Setting Tracting Engine Valves.

EDITOR THE PRACTICAL ENGINEER:

I have a question I would like to have answered through the columns of your valuable paper.

A 25 horse power traction engine fitted with a double ported valve and Wolf reversing gear was not properly set when sent from the factory. The valve stem was cone-shaped, fitted to the guide, and fastened with a nut in the steam-chest. The stem had a shoulder and a collar fitted with a set screw and at the end there was a nut 2 inches long by ½-inch wide that rested against the valve. How would you set the valve? Would you give any lead to the valve when the crank-pin is at dead centre, or would you set the valve so that it would just open the port as the crank passed the centre? I would like to have this question answered as there is some question as to the proper way to set the valve.

Hunter, Okla. H. M. B.

Put the crank of the engine on dead centre and examine the position of the valve by taking off the valve-chest cover. Loosen the eccentric and let its centre line make an angle of 90 degrees with the centre line of the crank. In this position, the valve is in its mid-position and should cover the ports. If it does not, then the position of the valve should be changed by moving it on the valve-rod.

In the case of a double ported valve, it will probably not be possible to observe the relative position of the valve and the ports, so that it is probable that the valve should be disconnected from the stem and its dimensions noted. The valve should be of such dimensions that when covering the ports, there should be some steam lap and exhaust lap.

Being assured that the dimensions of the valve are correct, fasten the valve to the stem, while the crank is on dead centre and eccentric 90 degrees from it, so that all the ports are closed. Then move the eccentric in the direction the engine is to run until the port just begins to open, when the eccentric should be secured to the shaft, and by replacing the valve-chest cover, the engine should be in condition to run. The reverse lever should be at the end of its stroke while the valve is being set.

The engine should have some lead because it is important

that the full pressure of the steam should be exerted at the beginning of the stroke. In fact, it was to attain this end that the valve was made double ported because the valve does not have to move far to obtain a good sized port opening with a given eccentricity.—[Ed.]

Pressure Corresponding to 26 Inches Vacuum.

EDITOR THE PRACTICAL ENGINEER:

How many pounds pressure are equivalent to 26-inch vacuum?

New Britain, Ct. M. B. N.

The absolute pressure corresponding to 26 inches vacuum is 1.93 pounds per square inch.—[Ed.]

Horse Power of Hoisting Engine.

EDITOR THE PRACTICAL ENGINEER:

Will you please answer the following question through the columns of your valuable paper: How is the horse power of a simple two-cylinder hoisting engine calculated?

Cable, Ill. E. H.

If steam follows the length of the stroke, the average steam pressure in the cylinder is easily obtained by noting the admission pressure, which when substituted in the horse power formula, will give desired result. It would perhaps be easier to find the horse power of each cylinder and multiply by two, in which case the number of strokes to be used in the horse power formula depends upon whether the engines are single or double acting.—[Ed.]

The Liberty Standard Turbine Cleaner.

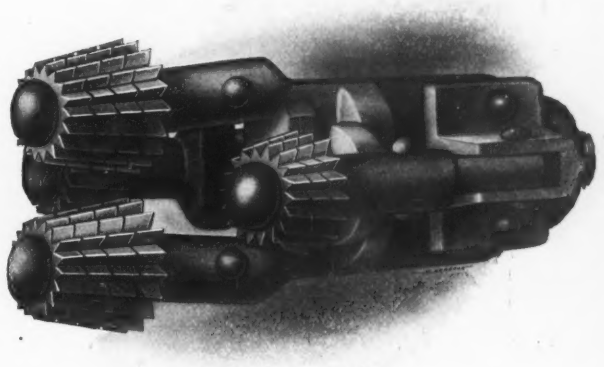
The natural outgrowth of the experience acquired in any line of manufacture is the development and improvement of the product manufactured. In this respect, the Liberty Manufacturing Company have not only had seven years of experience in the manufacture of water tube boiler cleaners but they have taken advantage of this experience and have developed a tool which will clean all kinds of tubes filled with all kinds and conditions of scale.

The Liberty Standard Turbine Cleaner, shown in the accompanying illustration, is the latest and newest type of cleaner and differs from the older types inasmuch as it has done away with the ball-bearing principle, which had always been a source of a great deal of annoyance, and uses, instead, a thrust bearing, which after a long series of experiments has been found the best for the purpose.

With this new construction, the cost of up-keep of the machine has been reduced to a minimum and not only has the life of the wearing parts been prolonged but the labor of replacing them is very much less than was required with the ball-bearing type.

The body of the Standard Liberty Turbine is made in one casting and within the casing is a spider which forms a bearing box containing a journal for the shaft. In one arm of the spider is an oiling chamber closed at one end, while the other end is provided with a ball valve through which oil is supplied to the bearing. The revolving part, or turbine wheel, is screwed into the rear end of the shaft, so that its weight will have a tendency to balance the weight of the cutting tool on the other end of the shaft. The vanes of the revolving part are all cut by patented processes, and being perfectly smooth, develop the highest efficiency. Both forward and rearward thrust of the revolving part are taken up by special, frictionless, fibrous material which runs in contact with metal washers and is practically indestructible to wear.

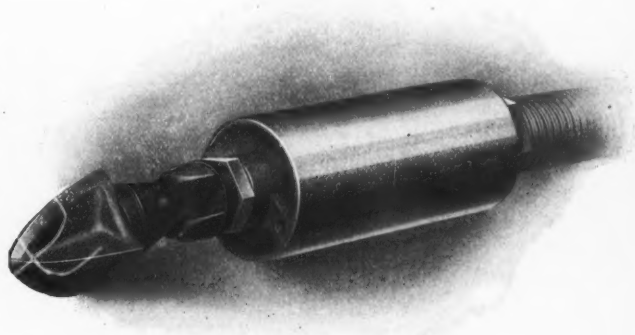
Back of the turbine wheel, the stationary part or nozzle piece is placed, which admits the water to the vanes or blades. This nozzle piece is screwed into the shell and locked in place



Liberty Turbine Cleaner for Light or Medium Scale.

by screwing in the hose coupling, as shown in cut. The hose coupling when used in bent tubes is attached direct to the hose so as to make the machine as short as possible. On machines for straight tubes, either this special coupling is used or one having standard pipe threads, the latter being furnished unless otherwise ordered.

Where tubes are bent, a universal coupling is interposed between the shaft and the freely swinging arm head, shown in accompanying illustration, thus permitting the machine to work equally well in either straight or curved tubes. These



Liberty Turbine Cleaner for Very Hard or Heavy Scale.

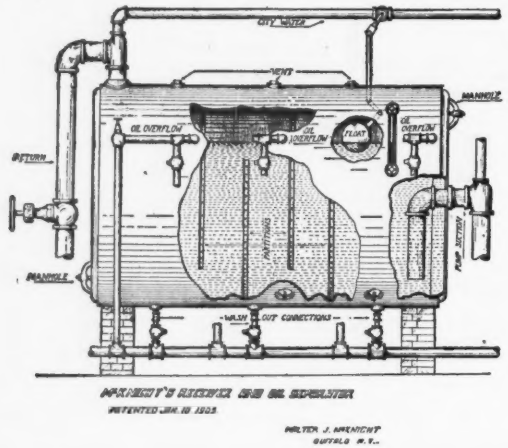
cutting heads are used primarily for light scale; for heavy scale, special cutting heads are furnished to meet special conditions, one of which is shown attached to the turbine.

The first machine of this new type that was built was put in service in one of the large steel plants in Pittsburgh, where it ran continuously day and night for several months and the only repair made during that time was the replacing of the bushing. The Liberty Manufacturing Company, 6409 Susquehanna Ave., Pittsburgh, Pa., are the manufacturers.

McKnight Receiver and Oil Separator.

There are very few steam plants that do not in some way make use of the exhaust steam from the engines for heating purposes and it has always been a serious problem to know just what to do with the return water of condensation so that it can be returned to the boiler with all its oil taken out.

The McKnight Receiver and Oil Separator, as shown in the accompanying illustration, is something new on the market and is intended to be used in connection with heating systems for running the returns back to the boilers. It does not take the cylinder oil out of the exhaust steam in the usual manner in which it is generally done; but is connected to the heating system at a point where the returns or condensation returns to the basement.



Its operation is as follows: After the steam has passed through the heating system it returns to the basement and flows into the receiver tank, which has been previously filled with fresh water. As the exhaust steam is condensed back into water, the cylinder oil has also returned to its original state and as oil will float on the top of the water, it flows out of the tank through the oil overflow pipes. The action of condensed water in the receiver is down one partition and over the other partition, and so on, during which time the oil separates from the water and by the time it gets to the pump suction pipe nothing but pure water remains.

The advantage of this method is that since the oil and water are both condensed, the positive action of gravity does the separation, whereas if the oil is separated from the steam when they are both in the form of a vapor, it becomes a more uncertain proposition.

As will be noticed, there is a float connected to the city water line which admits water according to the amount of leakage in the system. In case the water should become shut off or the float disabled, the pump is prevented from pumping the receiver empty, because when the water level drops to the centre of the ell in suction pipe, the pump will get air through the top of suction, instead of water through the bottom and consequently no cylinder oil can ever be pumped into the boilers.

Should the cylinder oil become heavy with sediment it will sink to the bottom, the same as it would in a boiler, but the natural flow of the water in the tank will cause it to flow down under one partition and over the other partition, so that it will come to the surface again and will be drained away as before.

The receiver and oil separator is also useful in connection with ice plants where the water of condensation must be especially free from oil and it can be used as a hot well in a condensing plant where the surface condenser is used.

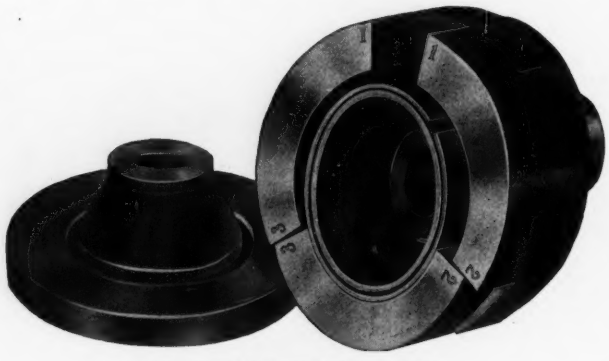
They are built in all sizes to meet the requirements of the plant. For further information, address the manufacturer, Walter J. McKnight, 179 Washington St., Buffalo, N. Y.

The Stayman Self-Expanding Pump Piston.

The efficiency of a pump depends chiefly upon the manner in which the steam pressure in the steam cylinder is utilized in the water cylinder. If there is any slip due to the leakage of water past the piston in the water cylinder, then the steam pressure in the steam cylinder is not utilized to its maximum amount. It is, therefore, very important that the water pistons shall be tight and at the same time not eat up any power with friction.

The Stayman Self-Expanding Pump Piston is shown in the accompanying illustration and has been designed to answer all these requirements and is especially adapted for use in high-pressure service. It consists of one inside spring ring and three outside packing rings. The inner spring ring is composed of phosphor-bronze and presses against the inside of the packing rings. The packing rings are made of a special high temperature anti-friction metal cut in three sections with long laps and wide bearing on the sides. These rings are turned the size of the cylinder and are not sprung but fitted in place, giving a true circle for the bearing.

The inner spring ring allows the expansion and contraction of the interlocking segments so that they automatically adapt themselves to variations in temperature and any unevenness in the cylinder. The packing rings are interlocking and are prevented from turning by means of radial dowel pins, thus insuring water tightness.



Stayman Self-Expanding Pump Piston.

From the above description it will be noticed that the pump packing consists of but four simple parts which are built not to break in the most severe service. The pressure of the inner ring is so distributed that the sections of the packing are against the walls of the cylinders just tight enough to form a true bearing with a minimum of friction, insuring tightness with a minimum of wear.

This piston packing can be placed on any kind of piston and

a large number are being put on feed pumps, plunger pumps, pumps for steamships and pumps for hot water and chemicals. The Stayman Manufacturing Co., 143 Liberty St., New York City, are the manufacturers.

The Acton Separator and Grease Extractor.

The general use of high-speed engines in connection with priming boilers and the use of long lines of pipes demands an apparatus that will automatically separate the water from the steam before it enters the engines, thereby increasing the efficiency and durability of the engine. In non-condensing plants, where the exhaust steam is now almost universally used for warming buildings or for heating the feed water, it is of the utmost importance that all the grease, oil or dirt be removed before it is allowed to enter the heating pipes, radiators or feed-water heaters.

Acton Steam Separator and Oil Extractor.

Of the various methods used for performing this separation, the accompanying illustration represents the Acton Separator and Grease Extractor which has been the result of many years' experience in the manufacture of engineering specialties. It consists of a cast-iron body, the interior of which is accessible at all times for cleaning purposes. The steam on entering the separator strikes a circular baffle plate which gives it an undulating motion along the plate. This causes the largest amount of water or grease in the entering steam to adhere to the plate. The steam then takes a downward course along the baffle and enters the receiving chamber through a circular plate filled with holes, and the steam there takes a 180 degree turn upward. If there is any water or grease left in the steam, this abrupt turn tends to throw it downward in the receiver. The steam then passes up through the interior of a copper wire basket of fine mesh and must pass through it before leaving the separator.

The separation of the water and grease from the steam is thus performed in three steps. The greater part of the water and grease in the steam adheres to baffle plate and runs down into the receiving chamber below. If any water or grease still remains in the steam, the course of the steam in turning through an angle of 180 degrees will tend to throw it into the receiving chamber and should the oil or water be in very finely divided particles and still refuse to leave the current of steam, then the copper screen will take care of this.

The length of the baffle plate is made three times the length of the opening and the whole area of the separator is made so that the velocity of steam is materially reduced through the separator, thus increasing the efficiency of separation.

The grease does not in any way clog up the screen because all the worst smudge has been taken out by the baffle plate but in order that the surfaces should be kept at their highest separating efficiency, they can be lifted out by simply removing the top cover and cleaning in boiling soda water. To replace, it is only necessary to drop the baffle in place and screw on the top cover.

These separators are being placed in a number of New England cotton mills and throughout the East and are manufactured by Mr. John Acton, 118 John St., Brooklyn, N. Y., who guarantees the removal of 95 per cent. of all the water and oil in the entering steam. Other specialties manufactured by him include Acton's reducing valves, balance valves, atmospheric exhaust relief valves, pump governors, steam traps and damper regulators.

Tenth Anniversary of Quaker City Association, No. 1, N. A. S. E.

Quaker City Association, No. 1, N. A. S. E., celebrated its tenth anniversary on Saturday evening, November 18th, at Maennerchor Hall, Phialdelphia. There were over 125 engineers and their friends present and as they gathered around the banquet table, which was set in the shape of an E, the assemblage presented an inspiring sight.

Mr. Richard Pape acted as toastmaster and kept everything moving along at a lively rate. Addresses were made by Ernest C. Fox, father of Quaker City Association, E. Caldwell, James S. Gillespie, G. F. Duemler, president of Northeast Association, No. 20, John Coe, president of Tacony Association, No. 9, Ole Hanson, president of Merrick Association, No. 12, William McLaughlin, president Quaker City, No. 1, Enoch Carless, treasurer Penna. State Association, John M. Lukens, Chief of Boiler Inspection, Philadelphia, and Past Supreme Chiefs Clifford P. Williams and Franklin R. Moore of the American Order of Steam Engineers.

Mr. E. C. Fox brought out the fact in his address that the number 13 was not unlucky because the first meeting of Quaker City was held on the 13th of the month with 13 members, while the tenth anniversary was held with exactly 100 members on the roll. Mr. E. Caldwell had many reminiscences to tell, his engineering career dating back to 1856, and he, together with Mr. James Gillespie, are looked upon as the grandparents of the Association. Mr. Duemler, Mr. Hanson and Mr. Coe each told of the success which their respective associations are having, and Mr. McLaughlin spoke about the credit that should be due to the older members of the N. A. S. E. for the success which they have had. Mr. John M. Lukens said that if there is anything which engineers should learn it is the fact that they should hang together and not let petty rivalries and jealousies creep into their actions. The result of this would be better salaries, better positions and more respect from the community at large.

The menu was finely prepared and nicely served and the entertainment features, provided by E. C. Fox, P. O. Johnson and Richard Pape, of the anniversary committee, kept everybody in a roar until the meeting adjourned with the singing of "Auld Lang Syne."

TRADE NOTES

EDITED BY THE ADVERTISING MANAGER

A maximum of power with a minimum consumption of fuel is the aim of engineering science. One of the most prominent advantages of the steam separator is the lessening of the loss of heat from the steam by taking away the water, which has a large capacity for absorbing heat, thus increasing the efficiency of the engine.

The Austin Separator Company, of Detroit, Mich., have just issued their new catalogue, No. 15, which explains the advantages of dry steam in steam engines and steam turbines and the methods by means of which their separators perform the work required of them. The Austin separators are manufactured in all sizes and shapes, including the vertical iron separator, horizontal iron separator, vertical steel separator, horizontal steel separator, horizontal and vertical iron and steel receiver separators and various forms of oil separators.

The Crandall Packing Co., of Palmyra, N. Y., have opened a store at 9 South Water St., Cleveland, O., and members of the engineering fraternity will find one of their old friends in charge—Mr. John M. Chapman, who for many years has been in charge of the Cleveland branch of the Garlock Packing Co.

Mr. J. H. Morris has been located in Chicago to take care of the interests of the Geo. W. Lord Company.

This Company has had, for many years past, a good business in Chicago, but has never had a resident representative until recently.

Mr. Morris has already increased the business and as he is a good fellow, he will, no doubt, make a number of new friends for Lord's Boiler Compounds, in Chicago.

A large plot of ground has just been purchased by the Lagonda Mfg. Co., Springfield, Ohio, upon which they will at once erect large new shops for the manufacture of their line of boiler tube cleaners, damper regulators, reseating machines and tube cutters. This will be the third time that the Lagonda Co. have been obliged to move to larger quarters on account of the constantly-increasing demand for their products.

Many modern automatic steam, water, air and vacuum specialties are shown in the latest catalogue issued by John Acton, 118 John St., Brooklyn, N. Y. Mr. Acton has been making engineering specialties for years and his close connection with power plants during those years has resulted in a number of engineering specialties which are just what engineers want. The Acton reducing valves for all classes of service, Acton balance valves, Acton back-pressure valves, Acton pump governor, Acton water separator and grease extractor are a few of the specialties which are described in the catalogue, which should be had by every engineer.

Nugent's treatise on "How to Oil an Engine," and their large catalogue of new and up-to-date oiling devices is worth a good deal more than the cost of a postal card, upon receipt of which a copy will be mailed free to any reader of THE PRACTICAL ENGINEER. Address W. W. Nugent & Co., 29 W. Randolph St., Chicago, Ill.

The Liberty Mfg. Co., 6409 Susquehanna St., Pittsburgh, Pa., have a handsome new catalogue now in press which will be ready in a few days. Every reader who wants one should send in his request at once. The new catalogue is devoted largely to boiler cleaning, but also contains descriptions of the Liberty Famous Electric Oil Filter, the Ideal Twin Strainer and the Faber Blow-off Valve.

"A Few Remarks by Father Knickerbocker" is presented in an attractive 16-page booklet just published by the Peerless Rubber Mfg. Co., 16 Warren St., New York. It tells the history of Rainbow Packing in a more interesting manner than we have previously heard it, and it also tells of the rewards paid by the company to engineers who tell them of unscrupulous dealers who substitute inferior packings and bill them as Rainbow. Write for a copy to The Peerless Rubber Mfg. Co., 16 Warren St., New York City.

The Collins Regulator Co., Conshohocken, Pa., inform us that they now have a highly improved damper regulator which will operate on less than one pound change of pressure; they also say that they are installing a large number of these machines with highly satisfactory results. This concern makes a specialty of purchasing old or unsatisfactory regulators, which they take in partial payment for their own make of regulators.

An all-metallic rod packing, which it is said can be applied to any stuffing-box, by any engineer in three minutes; which requires no measurements; no machine work; which will stand years and years of service and is practically frictionless is a matter of general interest to engineers, and is likely to make a lot of the boys sit up and take notice, and some of the boys from Missouri and others who do not, will say: "Show me." Then its up to the

Sample Can Free

Company that claims to have the goods, and in this case the Company stands ready to prove it, or quit claim.

The packing for which all these large claims are made is a comparatively new product called "Ambest," which is packed in tin cans like that shown in the illustration herewith, and to prove its goodness the makers have agreed to send a small sample can for trial to any reader of THE PRACTICAL ENGINEER, absolutely free. Those who wish to avail themselves of this opportunity should write at once to the Canfield Mfg. Co., 116 Lehigh Avenue, Philadelphia, Pa.

Frank L. Patterson & Co., 24 Cortlandt St., New York, are the makers of four specialties which they call their "Big Four." All these four are popular and are in service in every part of North America. They are the Patterson Feed Water Heater, Separator, Exhaust Head and Belt Pump, each of which is manufactured in immense quantities and sold as low as it is possible to guarantee the best material and perfect workmanship. A new illustrated "folder" has just been issued, which describes

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The following list contains the names of some of our customers among the leading builders of engines of all types. No higher endorsement of our goods could be mentioned than the patronage of these concerns, as they are necessarily in close touch with the most advanced engineering practice, and in many cases their officers are among the leading engineers of the country.

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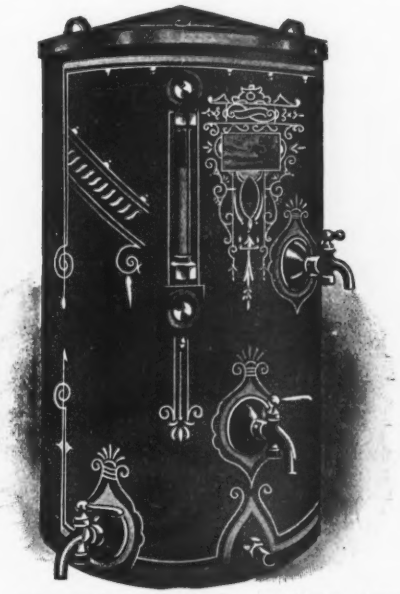
Ball & Wood Co.	New York City
Bates Machine Co.	Joliet, Illinois
Bessemer Gas Engine Co.	Grove City, Pennsylvania
Brown Corliss Engine Co.	Corliss, Wisconsin
Buckeye Engine Co.	Salem, Ohio
C. & G. Cooper Co.	Mt. Vernon, Ohio
Charter Gas Engine Co.	Sterling, Illinois
De La Vergne Refrig. Machine Co.	New York City
Erie Engine Works	Erie, Pennsylvania
Fairbanks, Morse & Co.	Chicago, Illinois
Fitchburg Steam Engine Co.	Fitchburg, Massachusetts
Foos Gas Engine Co.	Springfield, Ohio
Harrisburg Foundry and Machine Works	Harrisburg, Pennsylvania
Hoovens, Owens & Rentschler Co.	Hamilton, Ohio
International Power Co.	Providence, Rhode Island
Macintosh, Hemphill & Co.	Pittsburg, Pennsylvania
Murray Iron Works Co.	Burlington, Iowa
Nagle Engine and Boiler Works	Erie, Pennsylvania
New Era Gas Engine Co.	Dayton, Ohio
Olds Motor Works	Detroit, Michigan
Otto Gas Engine Works	Philadelphia, Pennsylvania
Power and Mining Machinery Co.	Cudahy, Wisconsin
Providence Engineering Co.	Providence, Rhode Island
Putnam Machine Co.	Fitchburg, Massachusetts
Ridgway Dynamo and Engine Co.	Ridgway, Pennsylvania
Russell Engine Co.	Massillon, Ohio
Springfield Gas Engine Co.	Springfield, Ohio
Struthers-Wells Co.	Warren, Pennsylvania
The De Laval Steam Turbine Co.	Trenton, New Jersey
The Filer & Stowell Co.	Milwaukee, Wisconsin
Vilter Manufacturing Co.	Milwaukee, Wisconsin
Watertown Steam Engine Co.	Watertown, New York
Weber Gas and Gasoline Engine Co.	Kansas City, Missouri
Wellman-Seaver-Morgan Engineering Co.	Cleveland, Ohio
Westinghouse Machine Co.	Pittsburg, Pennsylvania
William A. Harris Steam Engine Co.	Providence, Rhode Island
William Tod & Co.	Youngstown, Ohio



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the "Big Four" and tells briefly of some of their advantages. Every engineer or steam user who is interested in any of these four power plant auxiliaries should drop a postal card at once to the address given above.

There is food for thought for every man who has anything to do with belts, in the following letter from The Ben. F. Slack Brass Mfg. Co., dated,

DENVER, COL., Oct. 18, 1905.

STEPHENSON MFG. CO., Albany, N. Y.

Gentlemen: Your favor of the 13th inst. received, and contents noted, and in regard to the same will say that you may duplicate our last order for STEPHENSON Bar Belt Dressing. We do not use very much and a little lasts a long time. Our last order was ten or fifteen pounds. Anyway, please send that much by freight.

Stephenson Bar Belt Dressing is the best we have used yet and we do not care to make a change, and have not used any other.

Yours very truly,

THE BEN. F. SLACK BRASS MFG. CO.,
per Lohf.

The Stephenson Mfg. Co. keep a large office force busy sending free samples of either the Red Label Brand for Leather Belts or Green Label Brand for Rubber or Canvas Belts to those who enclose a two-cent stamp and ask for same.

The adoption of STEPHENSON usually follows the test.

If you have never tried it you are missing an opportunity each day you delay.

Users of steam power and engineers generally will be interested in the new catalogue just issued by the Fishkill Landing Machine Co., Fishkill-on-the-Hudson, N. Y., in which are shown the various styles of Corliss engines built by them.

The book is attractively designed and printed and finely illustrated throughout and contains much valuable information for those in charge of the modern steam plant, and would make a valuable adjunct to any engineer's library.

Following a very complete description of the engines built, the several parts are shown, including the valve gear and vacuum dash pots, which have contributed so largely to the popularity of the Fishkill type of Corliss engine.

A long list of references given lends additional emphasis to the Company's statement that their product is unsurpassed in point of economy, close regulation and noiseless operation.

The Fishkill Landing Machine Company will galdly send copies of their new catalogue to engineers and others interested, upon application.

In a competitive test in one of the largest plants in the West, to determine the actual variation of pressure with the use of Pump Governors on a large Duplex Tandem Compound Pump of 3,000,000 gallons capacity, the one which showed the least variation was the Williams' Governor, which is manufactured by the Williams Gauge Company, Pittsburgh, Pa. This governor maintained the pressure on the pump with an actual variation of less than two pounds. The others, which were tested, would not operate under three and one-half to six pounds variation.

This governor is also used by the United States Government, where it was selected after numerous tests.

The Williams Gauge Company, of Pittsburgh, Pa., have reported the sale, within the last six months, of 520,000 horse power Safety Feed-Water Regulators. Among the purchasers are the Philadelphia Rapid Transit Co., Illionis Central Railroad, New York Central and Hudson River Railroad, Delaware & Hudson Co., the Erie Railroad, Proctor and Gamble, Carnegie Steel Co., American Steel and Wire Co., etc.

The demand for this Regulator is increasing wonderfully. The claims made for it by the above Company, substantiated by the experience of its users are, that it will produce a fuel economy of from 4 to 12 per cent., a guaranteed assurance of dry steam constantly, and increased boiler efficiency. It is used on about 3,500,000 horse power of steam boilers in the largest plants in the country, and has been on the market for upwards of seven years.

This Company also manufacture a Steam Operated Trap, which they claim is the only trap with a valve which gives a full pipe opening instantly.

Mr. Earl A. Wheeler, of Sharon, Pa., the designer and patentee of the Wheeler boiler, has had a practical and theoretical knowledge of steam boilers for the past forty years and has developed a boiler which gives dry superheated steam and a consequent greater efficiency.

The Wheeler boiler is made in two designs: one for coal and the other for blast furnace gas. As a proof of their popularity, the following are a few of the plants equipped with them: Republic Iron and Steel Company plants at Thomas, Ala., New Castle, Pa., and Youngstown, Ohio; Illinois Steel Co. at South Chicago, Ill., American Tin Plate Co., at Sharon, Pa., Carnegie Steel Co., at Niles, Ohio and Sharon, Pa., Roane Iron Co., Rockwood, Tenn., Dunbar Furnace Co., Dunbar, Pa., Pickards, Mather & Co., Cleveland, Ohio.

W. W. Shilling is the general sales agent of the boiler and requests for catalogues or other information should be addressed to him at Sharon, Pa.

The Williams Gauge Company have opened an office at 311 Hennen Bldg., New Orleans, La. It is conducted by Mr. Charles L. Smith. Any inquiries for the Williams Feed Water Regulator, Steam Trap and Pump Governor directed to Mr. Smith will receive his prompt and careful attention.

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Wanted A few good and competent engineers along the Ohio, Mississippi and Kanawah Rivers, to sell the best thing on earth. This can be done after working hours and between times. Address
J. L. TILLMAN
521 Colburn Street, Toledo, Ohio

Wanted Salesmen traveling among engineers to sell the France Metallic and Fibrous Packings. Good inducements on unoccupied territory, Address
FRANCE PACKING Co.
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Wanted. Agents and Steam Specialty men to handle the Swan Patent Piston and Packing. The best ever made. George P. Rogers, 305 Bartlett Bldg., Atlantic City, N. J.

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1—16" x 16" Ball & Wood Automatic.
1—16" x 16" Greene.
1—15½" x 15" Armington & Sims Automatic.
1—15" x 30" Buckeye Automatic.
1—15" x 20" Russell, Four (4) Valve.
1—15" x 18" Taylor-Beck.
1—14" x 20" Russell, Four (4) Valve.
1—14½" x 15" Armington & Sims Automatic.
1—14" x 24" Payne Automatic.
1—13" x 22" Buckeye Automatic.
And many others. Stock is constantly changing.

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Six (6) 150 H.P. Vertical Manning Boilers, 135 lbs. Steam.
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Two (2) 180 H.P. National Water Tube, practically new.
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2—60" x 18' " "
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Steam Pumps up to 12" Suction.
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